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The Spawning Habits, Eggs and Larvae of the Sea Raven, *Hemitripterus americanus*, in Southern New England [1]

By Herbert E. Warfel and Daniel Merriman

Introduction

Although the sea raven, *Hemitripterus americanus* Gmelin, has been known to science for more than 150 years, comparatively little has been recorded about its early life history. Bean (1897, *et. seq.*) made observations on the eggs of this species in the New York Aquarium on November 29, 1897, Tracy (1910) mentioned a large specimen with ripe ova taken off Rhode Island December 22, 1908, and Huntsman (1922) recorded young collected in the Bay of Fundy in the summer. Bigelow and Welsh (1925) reported ripe females taken in November and December from southern New England, as well as 1¾-inch (45 mm.) fry which were collected from the bottom in the same region during the summer. Bigelow and Schroeder (1936) provided additional evidence that *H. americanus* is a late fall and early winter spawner by reporting that specimens taken on Nantucket Shoals in June had gonads only partially developed. They also discussed early growth and the number of eggs per female, citing observations both from southern New England and the coast of Maine.

Deposition of the Eggs

On October 31, 1943, large eggs, which later proved to be those of *H. americanus,* were discovered attached to a sponge, *Chalina* sp., in the course of field observations on a commercial fishing vessel off the coast of Rhode Island. These eggs were encountered regularly in the same region during the ensuing months until late January, 1944. The sponges were taken in trawl nets at depths of 10 to 15 fathoms on bottom consisting of hard sand and gravel overlaid by shells and small stones. Along the southwestern Rhode Island coast these depths occur from 1 to 3 miles from shore. The temperatures of the water on the sea bottom during the months that these collections were made ranged from 14.0° C. down to 2.9° C., a variation of 11.1° (Table I).

Table I

Field Data Recorded on the Dates when Eggs of *Hemitripterus americanus* were Collected

Date	Locality	Distance from shore	Depth	Bottom temp., °C.
X-31-43	3 mi. S. Green Hill, R.I.	3 mi.	26 m.	14.0
XI-21-43	2-7 mi. ESE. Watch Hill, R.I.	1-3 mi.	18-22 m.	11.0
XII-19-43	5-8 mi. ESE. Watch Hill, R.I.	1-3 mi.	18-26 m.	6.1
I-23-44	1 mi. S. Noyes Point, R.I.	1 mi.	18-27 m.	2.9

The eggs of *H. americanus* were deposited without exception in compact clusters at the bases of the upward-growing, finger-like branches of the sponges (Fig. 1). They were difficult to dislodge from that location, being

[1] The authors acknowledge with pleasure the generous cooperation of the Captain of the Port of New Haven. They are also greatly indebted to Captain Ellery Thompson of the vessel "Eleanor," out of Stonington, Conn., and the staff of the Bingham Oceanographic Laboratory for assistance in various phases of this work.

held in place both by their central position as well as by their own adhesive qualities. The association between the sponge and the eggs of the sea raven seemed to be definite and well established, inasmuch as careful examination of the contents of many trawl hauls failed to reveal the eggs in any other situation.

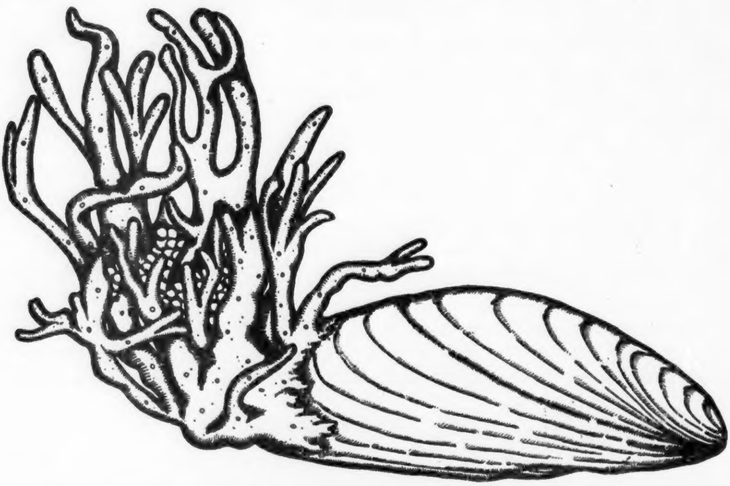

Fig. 1. The relationship between a typical cluster of *H. americanus* eggs and the sponge, *Chalina* sp. Drawing by Pfc. R. W. Head.

Chalina is also used for egg deposition by the 18-spined sculpin, *Myoxocephalus octodecimspinosus*. The eggs of this species were encountered much more commonly than those of *H. americanus* later in the same period. Although considerably smaller in diameter, they were more obvious because the clusters were seldom as centrally deposited near the base of the sponge; instead, they frequently surrounded parts of a number of branches and therefore were visible without spreading the "fingers" apart. Furthermore, the size of the clusters as well as the color of the eggs, which varied from green to purple, made them immediately apparent on even the most casual observation. Indeed, examination of the stomach contents of *Gadus morhua,* taken in the same trawl hauls, revealed the fact that cod sometimes "graze" on the sculpin eggs laid in this situation and in so doing take in pieces of the associated sponge.

The eggs of the sea raven, on the other hand, were always extremely well concealed. As a matter of fact, they might have remained undiscovered if the sponge itself had not been one of the objects of the collecting trips. Primarily because of their position in the sponge, but also as a result of their color (a pale yellow, amber or light orange, which approximates the living sponge), these eggs probably escape detection and are relatively free from danger of many types, particularly demersal predators. Even for some time before hatching, when the appearance of the clusters was darker due to the increasing pigmentation of the embryos, the eggs were in no way obvious. It

also seems probable that the position of the eggs from 2 to 6 inches off the bottom is favorable for development.

The average number of eggs per cluster for five batches which were counted was 242, the range being from 141 to 478. The mean diameter of 822 eggs from six clusters was 3.9 mm., the extremes in sizes ranging from 3.75 to 4.09 mm. These measurements agree with Bean's (*loc. cit.*) estimate of $\frac{5}{32}$ of an inch. Each egg was covered with a tough, slightly opaque egg membrane 0.1 mm. thick. Definite circular depressions or concavities characterized the membrane in most cases—the result of the compact nature of the clusters and the consequent pressure from adjoining eggs. Associated with the nature of the membrane was the highly adhesive quality of the eggs in each cluster, considerable force being needed to tear them apart and to free them from the sponge. The eggs were extremely resistant to damage—a fact which is also probably associated with the nature of the membrane. This was demonstrated when several clusters, which were transported to the laboratory attached to the sponges packed only in ice, were still alive 24 hours later.

Maturation of the Gonads and the Time of Spawning

The present observations on *H. americanus* suggest answers to three questions that Bigelow and Schroeder (*loc. cit.*) raised, either directly or by inference, in their consideration of this species. One question involves the date and duration of the spawning season; another deals with the number of times spawning takes place during a year; and a third concerns the number of eggs per female. These authors believed the spawning period to be late fall and early winter, since they captured ripe females in the waters of southern New England at that time. But in addition they noted that a 20-inch female taken in April off the coast of Maine had eggs of two size-classes, 3.0 and 1.5 mm. in diameter respectively. Because the two types of eggs were so obvious at this season, they were led to suggest that the species might spawn more than once during the year. They believed that the species was prolific because of the abundance of eggs carried by the Maine specimen, a number they estimated to be 10,000, presumably of both size-classes.

It would seem that Bigelow and Schroeder closely approximated the spawning season for southern New England. Mid-October to late December probably delimits the period in Long Island Sound. The inception of the season in 1943 is affirmed by the fact that the first eggs were encountered in late October, when a single cluster was found in a considerable collection of *Chalina*. The early stage of development of the embryos of the first collection (see below), considered in conjunction with the relatively high temperatures at that time of year, indicated that those eggs had not been long in the water. Also, eggs taken from females collected throughout the previous spring and summer were progressively larger as the season advanced until October, when those from one unspawned fish were over 4.0 mm. in diameter (Fig. 2). A safe estimate, then, would be that the first eggs were laid in the latter half of October in the Long Island Sound region in 1943.

That the last eggs were laid in late December, is indicated by the fact that no eggs in the January 23rd collection were in as early a stage of development as those taken in October and November. Owing to descending temperatures at this season (Table I), it is reasonable to assume that embryos

which were as far advanced as the specimens taken in January had been in the water considerably longer than those taken in a comparable degree of development in the preceding collections. This reasoning, together with the fact that Tracy (*loc. cit.*) encountered a ripe female in late December, indicates that the end of the spawning period was near the latter part of that month.

Examination of ovaries of mature fish preserved in 10% formalin revealed two types of eggs which were clearly distinguishable in the summer and early fall. They differed in size, appearance, and general texture. For example, the larger eggs from a specimen (No. 3305) collected in September, 1943, were firm, well filled with yolk, yellowish in color, and ranged from 0.79 to 2.18 mm. in diameter. The smaller eggs were whitish, deeply embedded in the follicles, and comparatively fragile owing to their soft membranes.

Large females collected in early spring, March and April, 1944, had typical "spent" ovaries. These were characteristically flaccid and had small eggs similar to those described above as belonging to the smaller size-class. The ovaries became increasingly compact and the eggs larger as the season progressed, so that by June it was possible to distinguish the two egg size-classes.

The larger eggs of course increased in size as the spawning season approached (Fig. 2). An ovary from a fish 30.5 cm. in total length (No. 2303), collected June 15, 1943, was fairly compact and the mean diameter of the eggs of the more prominent category was 1.07 mm. The ovary of another fish 25.5 cm. in total length (No. 2468), collected August, 1943, was similar in gross aspect and the larger eggs averaged 1.09 mm. in diameter. Two individuals 27.0 and 25.5 cm. in total length (Nos. 3304 and 3305), taken on September 12, 1943, had eggs which were 1.62 mm. in mean diameter. Another individual, taken September 21, 1943, 35.5 cm. in total length (No. 3595), carried eggs that averaged 2.11 mm. The eggs from a fish 38.0 cm. in total length (No. 3859), collected on the day the first egg clusters were found, October 31, 1943, averaged 4.1 mm. in diameter.

Small females under 25.0 cm. in total length, when collected in the spring, had compact ovaries whose outer tissue was relatively firm and which contained small eggs. Apparently females of that size had not yet spawned.

It is highly improbable that *H. americanus* ever has more than one spawning period during a year in the waters of southern New England. The size of the eggs from fish taken in the spring, as compared with those observed just prior to spawning in the late fall, indicates that they are approximately 4.0 mm. in diameter immediately before deposition. Inasmuch as the eggs in spent ovaries of fish collected in the spring resemble eggs of the smaller size-category in the more nearly mature organs, it seems reasonable to assume that these are the mature eggs which will be deposited in a succeeding season.

Counts of the number of eggs per ovary were obtained from the same individuals listed above. The number of eggs of the large size-category ranged from 1039 (No. 3304) to 3330 (No. 3595). In general the number per ovary seemed to be associated with the size of the fish. Thus the smallest number were taken from a female 27 cm. in total length, and the most came from a female 35.5 cm. long. However, variations from this trend existed, as is manifest by the fact that one female 25.5 cm. in length carried 1980 eggs per ovary.

Careful counts of the eggs in both size-categories from females 25.5, 30.5,

and 35.5 cm. in length indicated that the total number of eggs per ovary averaged approximately 7500, the range being 7036 to 7878 for these three specimens. However, a single apparently aberrant individual had a total of 22,194 eggs per ovary. Doubling these values gives a total of 15,000 eggs per specimen for the more normal fish, and almost 45,000 for the probably abnormal female.

When the number of available eggs per female is compared with the number of eggs per cluster, it becomes apparent that not all of the eggs are deposited at one time. The average number of maturing eggs was approximately 4400 per female, while the average number of eggs per cluster was roughly 250. In general, therefore, 17 to 18 clusters are deposited by a single female per season.

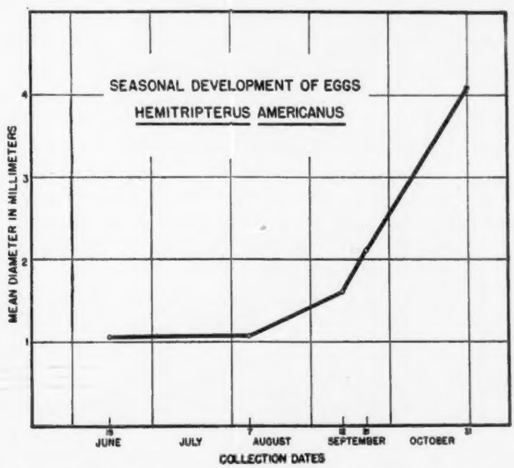

Fig. 2. The increase in diameter of the developing eggs of *H. americanus* from June through October.

The female taken by Bigelow and Schroeder (*loc. cit.*) off Maine in April is at variance with those from southern New England. As indicated above, the fish from Long Island Sound provide no evidence of more than a single spawning period each year, and it does not seem likely that the same species in the Gulf of Maine would differ in this respect. A possible explanation of the striking difference in egg-size at this season is that the species may spawn at a different time in the colder water off the Maine coast than in the warmer waters to the westward. Thus it might spawn earlier—i.e., late summer and early fall, in the Gulf of Maine, although eggs 3 mm. in diameter apparently reach the deposition size of approximately 4 mm. in the space of a few weeks during October in southern New England (Fig. 2). Or it might spawn later—i.e., in the spring, to the eastward. The latter alternative seems reasonable from the size of the eggs of the larger category in Bigelow and Schroeder's specimen, and it might be that the colder environment would preclude the full maturation of the eggs in time for fall spawning. But this would mean that

the same species spawned and underwent embryonic development on a falling temperature in one region as opposed to an adjoining area where these processes occurred under conditions of rising temperature. Although unusual, certain salmonids offer evidence that this situation might exist. It is also conceivable that these authors encountered a female which had failed to release her eggs at the proper time and therefore gave a false impression of imminent spawning.

Developmental Stages

Eggs removed from a mature female shortly before spawning and fixed in 10% formalin characteristically showed three distinct regions inside the outer membrane. Occupying approximately 10% of the surface of the egg was an area dominated by small oil globules. This mass extended inward through a peripheral stratum of clear amber-colored yolk. In the center of the egg, and occupying a large portion of the volume, was a region of opaque yolk.

The eggs in the first cluster, discovered October 31, 1943, were all at about the same stage of development. The larval form was complete. The eyes were well developed, some even showing clear evidence of the earliest pigmentation. A median fin, beginning posterior to the head, continuing around the tail and extending anteriorly to the anus, was present; but no rays or regional differentiations were discernible at that stage. The gill arches were visible and the otic vesicles were clearly evident. The pectoral fin buds were well developed and numerous somites were apparent. Conspicuous accumulations of white material were present outside the yolk sac. These embryos approximated stage 21 of Oppenheimer (1937).

Four clusters containing a total of 1102 eggs were collected on November 21, 1943. One lot of these was in about the same state of development as those taken on October 31; the eyes were faintly visible through the shell and some were slightly pigmented. Another lot was evidently further advanced, additional eye pigment being apparent. A third cluster had much more completely pigmented eyes, and a fourth group was still further developed, body pigmentation appearing on the dorsal side for the first time.

On December 19, 1943, several clusters of eggs were observed and one lot was brought to the laboratory where an unsuccessful attempt was made to rear them. These were kept in aerated sea water somewhat below room temperature, but they died, a few each day, until January 3, 1944, when the last were preserved. The other clusters collected at that time were also brought to the laboratory alive and were used successfully for classroom demonstration.

The last date on which the eggs of *H. americanus* were encountered was January 23, 1944, three clusters being taken. These were brought to the laboratory in sea water and during the trip three eggs hatched. The embryos in all clusters were well advanced, which encouraged further attempts to hatch and rear them. One cluster was preserved; one was placed in cold aerated sea water on a window sill of the laboratory on January 24th; and another was put in a jar whose mouth was covered with gauze and which was attached to a floating buoy in Long Island Sound on January 25th. The eggs in the laboratory hatched, a few at a time, for several days on and after January 28th. Those in Long Island Sound hatched slowly until March 12th. None

of the larvae lived longer than a few days, those in the laboratory less than 48 hours, and the fish in the Sound probably longer, although it was impossible to check accurately since they could be visited only every week or ten days.

Observations of the hatching process under laboratory conditions indicated that the larvae characteristically emerged head first from a round opening slightly larger than the head but little if at all larger than the abdomen. Getting out of the shell was a slow and difficult process, and it seemed as if the animal had to await the absorption of a part of the abdominal yolk before it could free itself completely.

Fig. 3. *H. americanus* larva preserved in 10% formalin shortly after hatching. Drawing by R. F. Zallinger.

The larvae, when first hatched, were approximately 12 mm. in length, the range being from 9.9 to 14.1 mm. for 24 specimens (Fig. 3). The head constituted about 20-25% of the total length, and the diameter of the eye 40-45% of the head; the diameter of the pupil was approximately equal to the width of the iris. The median fin was continuous and ended very slightly in advance of the anus. Rays appeared in the region of the definitive caudal fin within a few hours, the ventral rays developing first. The pectoral fin was well developed, although so transparent as to be inconspicuous at first observation. The yolk sac was contained within the abdomen, and there was a prominent anal stalk. Myotomes were clearly visible, particularly in specimens that had just died, the average number being 38 to 39.

Under direct artificial light the newly hatched larvae had a light olive-green appearance, underlaid with a silvery guanin. There were no chromatophores on the ventral side of the abdomen and the yolk added an amber hue to the silvery color of that region. Chromatophores were most abundant on the dorsal side of the larval body, especially along the base of the dorsal fin. They were also scattered on the top and sides of the head, surface of the operculum, and at several points on the proximal portions of the median dorsal and ventral fins. A few chromatophores were apparent on the upper edge of the lower jaw, the anterior half of the circumorbital ridge, and on the ventral surface of the head—especially the anterior portion of the lower jaw and the region just posterior to the union of the branchiostegals. The posterior 3 to 4 mm. of the caudal region were colorless and more or less transparent. In specimens preserved in 10% formalin, the median and paired fins, as well as the peripheral part of the eye and parts of the head and body wall, were uniformly characterized by small, closely spaced, papilliform white dots; these

were readily apparent under low magnification, particularly with direct illumination against a dark background, and they gave a finely stippled effect to the regions concerned.

Addenda

After the manuscript of this paper had been accepted for publication, the authors were fortunate in securing the following additional and confirmatory data. While fishing on the commercial vessel "Eleanor" from ½ to 2 miles off shore in the vicinity of Noyes Point, Rhode Island, on October 26, 1944, a large collection of the sponge, *Chalina* sp., was taken in the net. In two drags 62 specimens of *Chalina* were obtained, and eight of these contained clusters of *Hemitripterus* eggs. These eggs ranged in color from pale orange or amber to a vivid or brilliant orange. The bottom temperature on this date was 14.4° C., which is in close agreement with the previous year's observations on temperature conditions near the inception of the spawning period (Table I). Subsequent examination revealed the fact that the eggs were all in relatively early stages of development, ranging from the formation of the blastodisc up to a stage where the optic vesicles were well developed.

It is also of considerable interest that for the first time the eggs of *Hemitripterus americanus* were discovered in association with another sponge, *Halicondria panicea* (Pallas). *H. panicea* has been collected in considerable quantities in much the same area in which *Chalina* is normally encountered, but heretofore no sea raven eggs have been found in association with this sponge. On this occasion the eggs were discovered in a piece of *H. panicea* approximately 200 cc. in volume. The eggs completely filled an irregular depression in the sponge, the resultant mass of adhesive ova thus forming an almost perfect mold of this cavity.

During the course of the day a considerable number (25 to 30) adult sea ravens were caught. All the females examined contained mature eggs. One specimen, a particularly large individual which was brought back to the laboratory, measured 50 cm. in total length (standard length 41 cm.) and weighed 5.8 lbs., which is more than any recorded by Bigelow and Welsh (1925).

It is of course well known that the sea raven often distends its abdomen when caught and superficially resembles the puffer, *Spheroides maculatus,* in this respect. However, the sea raven accomplishes this by swallowing large quantities of water. When the stomach of the individual in question was punctured and drained, the fish weighed 5.3 lbs—in other words it had a half pound of water in its stomach. Even after the water had been removed it was heavier than the record cited by Bigelow and Welsh (*loc. cit.*) of a specimen recorded by Storer which was 5 pounds in weight and was 25 inches long.

This large fish was a gravid female. Its ovaries weighed 350 gm. The total number of eggs was approximately 10,000, which agrees with the specimen collected off the Maine coast by Bigelow and Welsh (*loc. cit.*).

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Brief Record of Fishes from Central Northern Quebec

By L. R. RICHARDSON

THE freshwater fauna of the great area of northern Quebec to the east of James Bay and Hudson's Bay is relatively unknown, and on this account it is anticipated that the present brief list of fishes taken at Lake Wakonichi, Lake Mistassini and from the Bureau Lakes at Oskelaneo may be of some value, particularly in connection with the study of the distribution of the fishes of eastern North America. Collections from Lake Wakonichi are of interest as this lake is a headwater of the Rupert River system which drains from the highlands of central northern Quebec west into James Bay and is at present the most southerly system in central northern Quebec cut off from direct contact with the non-tidal waters of the St. Lawrence River system.

The Rupert River drains a long and relatively narrow watershed, of which a great part of the highland area is occupied by the large Lake Mistassini. The eastern boundary of the watershed is formed by a high, abrupt range of mountains separating this system from that of the Saguenay River, which enters the St. Lawrence system well below the limit of tidal water. The Nottaway River system extends from the western height of land of the Saguenay River watershed south of the Rupert River system and extends to the west to enter the southern end of James Bay. In this fashion it intervenes be-

tween the Rupert Rivert watershed, and the St. Maurice, Gatineau and other rivers to the south which are tributary to the St. Lawrence River and so isolates the waters of the Rupert River from the systems which drain the large area of southern Quebec. Lake Wakonichi enters Lake Mistassini from the south by a short run of rapids only 300 yards in length. It is a relatively narrow, deep lake, some 18 miles in length and for the greater part well under a mile in width. Such soundings as were made showed that much of the lake exceeds 60 feet in depth, while at the north end depths of 185 feet were found. The shores are generally steep and heavily timbered. Much of the margin of the lake is abrupt, stony and free from debris. Inlets are few and so far as was seen, of small size, commonly of only a hundred yards or so in length with the one exception of a single mountainous type of stream entering Lake Wakonichi close to the north end. This stream descends from a small lake higher up in the hills.

The number of species recorded for Lake Wakonichi is not large, and with the exception of *Pungitius pungitius* include only species which have been found at many places in the Appalachian and Laurentian waters of southern Quebec. *P. pungitius* is known to me only from the St. Lawrence River and from the waters of the Ottawa area. At the same time, the list contrasts slightly with that of the fishes of Lake Abitibi, a broad shallow lake in the Moose River watershed to the west of the Nottaway system and also a tributary of James Bay.

Dymond and Hart (1927, Univ. Toronto Studies, Biol. Ser., Pub. Ont. Fish. Res. Lab., 28: 1–19) have recorded the presence of 30 species of fishes in the waters of the Abitibi region, most of these being species characteristic of the Great Lakes. *Leucichthys nipigon* and *Amphiodon alosoides,* which are well-known species of the waters of Manitoba, were also recorded, and the presence of these species is considered by Dymond and Hart as pointing to partial westerly affinities or origins for the fauna of Lake Abitibi. Eight of the species recorded in Lake Wakonichi occur also in Lake Abitibi, but in view of the striking ecological contrast between these two waters, in the present state of our knowledge we can attach no more significance to the absence of *L. nipigon* or *A. alosoides* from Lake Wakonichi than to the absence of *C. namaycush* or *L. artedi* from the waters of Lake Abitibi, since these latter species in my experience have definite habitat preferences. On the other hand it may be possible even at this time to attach some value to the presence of *Rhinichthys atratulus, Semotilus atromaculatus,* and *Leucosomus corporalis* in the waters of Lake Wakonichi. These species are not recorded for Lake Abitibi, yet they are common species in the waters of southern Quebec where they exhibit little ecological preference and occur under natural conditions in streams, lakes and ponds. Their presence in Lake Wakonichi and their absence from Lake Abitibi suggests that these two waters have distinct origins for their fauna and that the eastern limit of the western fauna lies somewhere between these two lakes.

The region was visited in August, 1937. Many of the records are based on specimens taken in the late evening from the shallow water of a sandy cove close to the north end of the lake. In fact the examination of this strip of water with the aid of a flashlight was a valuable procedure since many

species not normally seen along the shore during the day came into this strip of shallow water for short intervals during the first half of the night and could be readily identified and even captured when necessary.

I wish to record my appreciation of the kindly interest and support given me by the late Professor H. B. Fantham, and the cooperation of Canadian Airways, of J. Midledge and V. Turley of Oskelaneo which made the trip possible.

List of the Fishes

Leucichthys artedi (Le Sueur).—Two small specimens, one 8.9 cm., the other 12.0 cm., were found dead on the shore at Lake Wakonichi. On several occasions small groups of 4 and more were seen swimming close to the bottom in 8 to 10 feet of water. Late in the afternoon, this species was frequently seen rising to the surface close to the shore. Small specimens were taken from the stomach of grey trout.

Cristivomer namaycush (Walbaum).—This species is one of the best known of the fishes in the larger lakes of northern Quebec and is commonly taken for food. It is a common species in Lake Wakonichi. In one week 20 specimens, ranging in weight from 3 to 6 pounds, were obtained by trolling in water at depths greater than 30 feet. The stomachs of 12 of the fish were empty. Of the remainder, 2 had eaten *Cottus b. bairdii* and the other 6 had been feeding actively on small *L. artedi*. It would thus appear that these two food species range well into the deep water of the lake at this time of the year.

Salvelinus fontinalis (Mitchill).—The speckled trout is a common fish of the waters of Lake Mistassini and Lake Wakonichi, as also generally of the lakes and streams of the majority of the watersheds draining this southern portion of central northern Quebec. Fingerling speckled trout were the only fish seen well up in the small inlets leading into Lake Wakonichi. Small trout of ¾ of a pound to a pound in weight were taken from the discharge and from the large inlet entering the lake at the north end. Many large specimens were seen jumping in the middle of the lake in the early evening. None were seen in the inshore waters.

Catostomus commersonnii (Lacépède).—This is the common sucker in the Province of Quebec where it ranges freely in the Appalachian, St. Lawrence River and Laurentian waters. Specimens were obtained at the Bureau Lakes near Oskelaneo. It is a common species in Lake Mistassini, and many specimens were taken at Lake Wakonichi, where schools of young suckers averaging 4.0 cm. in length were a very obvious feature of the mouths of small inlet streams and of the stony sections of the shore of the lake. Larger specimens were observed in shallow water late at night. These were usually solitary and were found feeding in rocky stretches even in the early hours of the morning.

Leucosomus corporalis (Mitchill).—The fallfish is a common species of Lake Wakonichi. Adult specimens were collected late in the evening from shallow water and were occasionally seen swimming in small schools in 8 to 10 feet of water during the day. These schools were commonly associated with small schools of *P. pungitius*. Young fallfish were found feeding in shallow water over rocky bottoms during the day. This species is common in the Bureau Lakes.

Semotilus atromaculatus (Mitchill).—This was probably the commonest minnow in the vicinity of the discharge from Lake Wakonichi and of the large inlet entering the lake nearby. Specimens up to 5 inches in length were numerous in some of the pools at the mouth of the outlet. The species is very common in the southern waters of the Province, but strangely enough, although carefully sought for, no specimens were obtained at Oskelaneo.

Rhinichthys atratulus (Hermann).—Black-nosed dace were found near the outlet of Lake Wakonichi. The species was common amongst rocks in shallow water. Specimens were also taken from the less disturbed pools on the outlet stream itself and from the larger inlet. It is a common species in the southern waters of the Province where it is found in lakes, ponds and streams.

Rhinichthys cataractae (Cuvier and Valenciennes).—The record of this species in Lake Wakonichi is based on two specimens which were taken and on several individuals seen in the outlet stream. Both of the specimens which were collected were adults still in high breeding colors. One specimen was found dying at the debouch of the large inlet at the north end of the lake. The other was taken by hand in shallow water late at night and at a point remote from any inlet. While the long-nosed dace has been commonly recorded for many locations in the southern waters of the Province, this is my first record of this species from a lake at a point remote from inlets.

Couesius plumbeus (Agassiz).—A single adult specimen of this fish was found dead on the shore at Lake Wakonichi. It was 12.0 cm. in length and bore the large reddish-orange patches, typical of the breeding fish, at the corners of the mouth and in the axillae. A second specimen, 8.0 cm. in length, was taken by hand in shallow water late at night. This species has not been a common one in collections from the southern part of the Province where it is known from some few lakes in the Laurentian area and from streams in the Appalachian district.

Esox lucius Linnaeus.—The species is common in Lake Mistassini where it is one of the valuable food species. In commercial practice it is split along the back, eviscerated and then dried in the sun. A single specimen was seen in the lake at the top end of the inlet entering the north end of Lake Wakonichi. The species is present in the Bureau Lakes area and is common in the larger waters of the southern part of the Province.

Percopsis omiscomaycus (Walbaum).—The presence of this species in Lake Wakonichi was rather surprising since it has been uncommon in the southern waters of the Province, where, although taken at many points in the St. Lawrence River Valley, it does not appear to penetrate far into the upland waters. Adult and young *P. omiscomacus* were found under stones in the shallow inshore waters in Lake Wakonichi during the day. A single adult was taken by hand at night in shallow water over a clean sandy bottom. Others were seen and it is apparent that the species moves freely during the late evening along the marginal waters of the lake.

Eucalia inconstans (Kirtland).—Brook stickleback were fairly common in the inshore waters at both Lake Wakonichi and Lake Mistassini. In some of the small rocky bays this was the commonest species. It is a fish found in pools and ponds throughout the southern waters of the Province at all elevations.

Pungitius pungitius (Linnaeus).—The nine-spined stickle-back was found in Lake Wakonichi. This is a species of limited distribution in the Province of Quebec where I have records of its presence only in the St. Lawrence River and in some of the tributary waters of the Ottawa.

Stizostedion vitreum (Mitchill).—This species is common in both Lake Wakonichi and Lake Mistassini and is a valuable food species. It is treated in the manner described for the northern pike. It is a common species in the southern parts of the Province and occurs in both lowland and highland situations.

Cottus bairdii bairdii (Girard).—This miller's thumb is a relatively common fish in the waters of Lake Wakonichi. Specimens were found in pools of brooks entering the lake and in the shallow water of the lake margin where this fish conceals itself among the stones. On one occasion specimens were found coming into marginal water barely deep enough to cover their bodies. The largest specimens were 10.5 cm. in length.

Additional species.—*Coregonus clupeaformis* (Mitchill) is a common species in the Bureau Lakes district and may possibly occur at Lake Mistassini where a fish of this type was described to me by Indians at the H.B. Post. *Lota maculosa* (Le Sueur) and *Perca flavescens* (Mitchill) also occur in the waters of the Bureau Lakes, but I could find no trace of them at Lake Wakonichi.

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Notes on the Early Life History of *Notropis girardi* [1]

By George A. Moore

THE Arkansas River shiner is a common minnow in the Arkansas River and its larger tributaries. It is a small species, the greatest recorded by its authors (Hubbs and Ortenburger, 1929) being 54 mm. for a female. Although *Notropis girardi* is usually found in the main channels of the larger rivers, it is occasionally taken in backwater pools where it associates with *Hybognathus placitus placitus* Girard, which is by far the most common fish of the Arkansas river system.

In the summer of 1940 two students, Mr. Melvin Grubb and Mr. Leland Gentzler, were assigned life history problems. The former was to try to obtain early developmental stages of *Extrarius aestivalis tetranemus* (Gilbert) and the latter was to do similar work with *Notropis girardi.* Although a deliberate effort was made to get information concerning the breeding habits and development of these forms, the eggs of *N. girardi* were discovered by accident and to date we have no clues leading to the clarification of the *Extrarius* problem. After some hours of diligent work we paused to plan a new "method of attack." While standing waist deep in the main channel of the Cimarron River near Perkins, Oklahoma, Mr. Grubb was holding a screen wire net (1/16 in. mesh) to allow the water to flow through. While idling in that manner "bubbles" of uniform size were collected in the net. Their persistence and uniformity attracted attention and upon examination they were found to be fish eggs in various stages of development. Some were fixed in formaldehyde and others were taken to the laboratory for observation.

In order to simulate the river current some eggs were provided with running water and others were placed in a finger bowl. The next day all had hatched but most of those in the running water were lost. The finger bowl specimens were in good condition and were reared to large juvenile stages for specific determination.

Since the time of spawning was suggested by Hubbs and Ortenburger to be early July, attempts to procure eggs began June 18, 1940, in order to be sure of getting collections at the time of spawning. Females taken June 18 were not ripe and not until July 12 was it possible to strip eggs from them. The first eggs were taken from the river on July 24. More were obtained the next day. At this time the river was higher than normal and very turbid (18,000 p.p.m.). The high turbidity was occasioned by rains ranging from .02 to 3.05 inches which had fallen in the Cimarron Valley above Perkins (Wahlgren, 1940).

No observations were made in 1941 but on July 11, 1942, eggs were taken from the river when it was again made turbid by heavy showers (2.02 inches at Stillwater, July 10 and 1.25 inches July 11). On July 25 of the same year the river was quite clear due to the fact that very little rain had fallen on the Cimarron watershed since July 11. In striking contrast to

1 A contribution from the Museum of Zoology of the University of Michigan and (No. 115) the Department of Zoology of the Oklahoma Agricultural and Mechanical College—a portion of a doctoral dissertation prepared under the direction of Dr. Carl L. Hubbs to whom the writer is indebted for criticisms and helpful suggestions. Thanks are due to Mr. Leland Gentzler who kindly presented his data to me at the time of his induction into the Armed Forces.

experiences of July 24 and 25, 1940, not one egg rewarded our efforts on July 25, 1942.

During the summer of 1940 a futile effort was made to induce laboratory spawning. Small schools of adult shiners were placed in aquaria and fed on commercial dog food which was readily eaten. Aquaria filled with clear water and others with muddy water were used in an attempt to determine the influence of turbid conditions on spawning activities. However, some factors undoubtedly were still lacking since the fish exhibited no spawning tendencies. The use of river water (somewhat saline) seemed to make no difference.

Under laboratory conditions the species exhibits a strong schooling tendency, often swimming about in fairly close formation. When a tile was placed in an aquarium containing clear water all the fish crowded together under it. This habit was less marked when muddy water was used.

Notropis girardi adults taken in July, 1940, were kept in laboratory aquaria until February, 1942, when some meddlesome person placed a sunfish (*Lepomis cyanellus*) with them. All specimens were eaten except one which became progressively thinner and finally died a few months later. Assuming that these fish were 1 year old at the time they were taken, *Notropis girardi* lives at least 3 years. Under the more rigorous river conditions the life span is possibly shorter.

Direct observations of spawning have not been made and it seems likely that this will be impossible since the time of spawning is apparently coordinated with high water and a consequent high turbidity. It is not improbable that the spawning behavior is similar to that of *Notropis longirostris* (Hay) described by Hubbs and Walker (1942), who also called attention to the similarity between the habitats of *Notropis sabinae* Jordan and Gilbert, *N. bairdi* Hubbs and Ortenburger and *N. girardi* Hubbs and Ortenburger with that of *N. longirostris*. It would be interesting to try to collect the eggs of these forms by means of a screen. Although sufficient data are not available for *N. girardi,* the two summers during which observations were made point strongly to the possibility that heavy summer rains stimulate breeding and in this respect *N. girardi* may be different from ecological analogs in other stream systems. Other factors such as temperature may also have importance, although the mean July air temperatures for two years (1940 and 1942) in Payne County are nearly the same—79.8 and 80.8 respectively (Weather Bureau data). A difference in spawning time of nearly 2 weeks in the two years (1940 and 1942) seems to be explained only by the fact that summer rains are uncertain in the Great Plains Region. The fish seem to withhold their reproductive products until environmental conditions are favorable to survival of the larvae.

The behavior of the newly hatched larvae strengthens this view. Larvae hatched from eggs the next day after being taken to the laboratory. The rate of development is very fast since nearly all were hatched in 24 hours in spite of the fact that many eggs in the blastodisc stage were found in samples fixed in the field. At the time of hatching the young carry a large yolk sac and exhibit a peculiar habit of moving vigorously to the surface. When the surface is reached all movement ceases as though the tiny fish were exhausted

by exertion. After settling to the bottom of the dish contact thereon seems to stimulate the animal to activity again and the process is repeated. This continues for about 2 days by which time the yolk sac is greatly diminished in size and horizontal movement is begun.

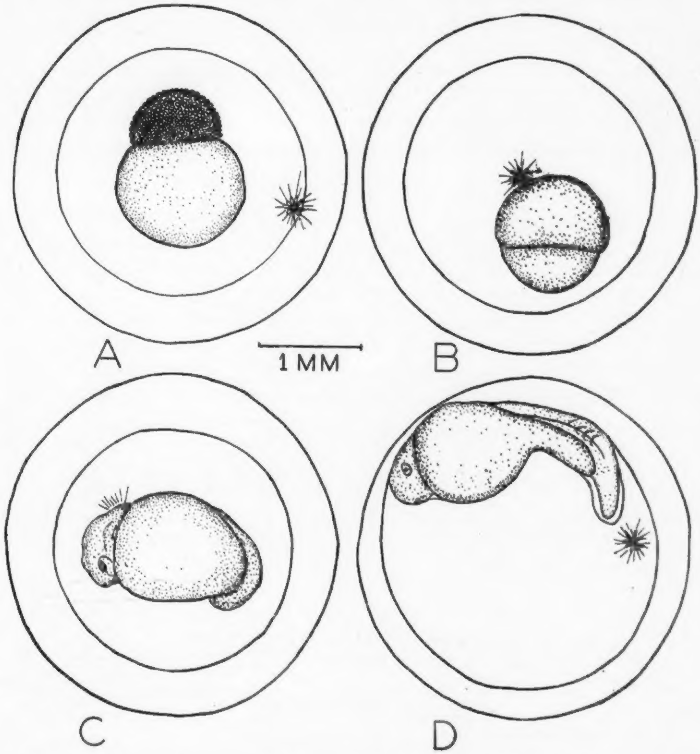

Fig. 1. Early development of *Notropis girardi*. All figures drawn with the aid of camera lucida. a. Blastodisc stage. b. Germ ring stage. c. Embryo with yolk sac. d. Embryo just prior to hatching.

Spawning must take place in the main channels. The eggs are fertilized and then swept by the current downstream to develop as they go. After hatching, vertical movements of the larvae doubtless are a contributing factor in preventing their destruction by the shifting sand and silt, so characteristic of Great Plains rivers, and from being devoured by bottom feeding species which doubtless find their food by means of chemical senses. Spawning at times of high turbidity likewise is a protection from predators which employ the visual sense because in very muddy water light penetration is practically nil (Higgins, 1932; Ellis, 1936). Since about 3 days elapse between the time of spawning and the time that the larvae are capable of

horizontal movement, the young must be swept many miles downstream from their parent locality.

The eggs are highly transparent and slightly in excess of 1 mm. in diameter exclusive of the gelatinous envelopes.

The gelatinous envelope of each egg bears a small depression which appears as a many rayed star suggesting the possible locus of sperm entry (Fig. 1; A-D).

A large yolk sac is carried by the embryo and the prolarva (terminology as suggested by Hubbs, 1943). The prolarval stage (Fig. 2) is very brief, not more than 3 days and possibly less. By the fourth day the yolk is practically absorbed and the mouth parts are correspondingly soon developed.

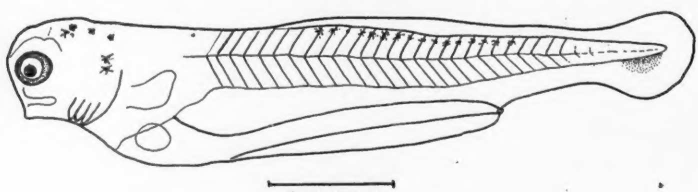

Fig. 2. Prolarva approximately 4 days old.

The caudal and pectoral fins make their appearance first (Fig. 2) followed by the dorsal and anal fins. The pelvic fin anlagen are last to appear (Fig. 3) and by the time they are in evidence the vertical fins and the pectorals have visible fin rays.

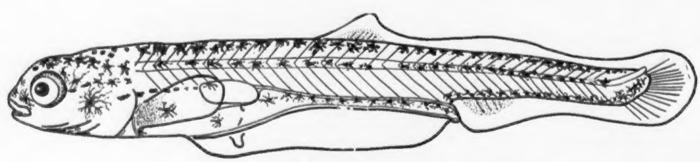

Fig. 3. Postlarva approximately 7 days old (drawing by Miss Rosemary Herald).

The air bladder is a conspicuous feature in larvae 7 days old and is easily seen from above as a silvery bubble.

The larval pigment areas arise in 4 well defined regions: a cephalic patch in dorsal position, opercular patch, a dorsolateral patch on each side just below the dorsal fin fold and represented by a single row of melanophores—one on each somite, and a lateral band is represented by a tiny melanophore on the anterior angle of each myoseptum.

Specimens were fixed at various ages and later measured in millimeters of total length. These ages and the average measurements are as follows: 4 days, 5.4; 7 days, 7.7; 22 days, 16; 40 days, 24.5; 59 days, 28; 6 mo., 23

days, 34.5; 7 mo. 15 days (13 specimens), 35.4 (28-39.5). When the fish had reached the latter age all were found dead of unknown causes and observations accordingly ended. These data show an average daily length increment of about 0.16 mm.

The rate of growth of *Notropis girardi* is somewhat faster than that of *Hybognathus nuchalis regius* Girard which Raney (1939) found to be 20 mm. in standard length after 60 days. *Notropis girardi,* although about the same size as *Hybognathus nuchalis regius* at the time of hatching, reached a total length of 24.5 mm. in 40 days. The faster rate of growth is probably due to higher temperature of the water in which the *girardi* eggs were kept. Oklahoma July air temperatures are much higher than New York April air temperatures.

Discussion and Conclusions

The spawning habits and larval behavior of *Notropis girardi,* in spite of the meagre data available at present, strongly suggest adaptations to silty Great Plains river environment. Some members of the genus *Notropis* spawn over gravel beds and may use the nests of other species (Raney, 1940; Hankinson, 1932). Under these conditions the eggs are washed into the interstices of the gravel where they become sticky and adhere to the gravel and sand. Similar behavior has been personally observed in *Notropis zonatus pilsbryi* Fowler in the clear streams of eastern Oklahoma. Such spawning behavior is possible because the shifting of gravel and coarse sand is not great and the interstices are large. In Great Plains rivers these conditions do not obtain and instead the bottom is one of very fine sand that is constantly shifting and in which the interstices are small—too small to contain even the 1 mm. eggs of *Notropis girardi* without smothering and abrasion.

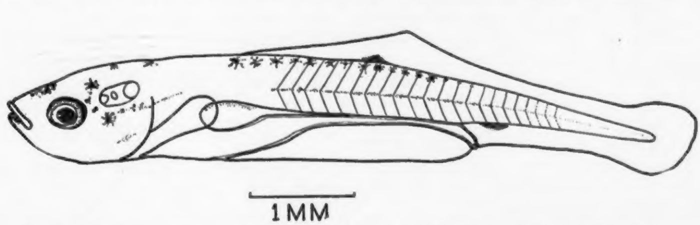

Fig. 4. Postlarva approximately 5 days old, probably of *Notropis percobromus.*

As soon as the larvae are capable of horizontal movement they are able to move out of the main channels where the necessary food is scarce, especially over shifting sand (as was indicated by Tarzwell, 1937). Very small young are frequently taken from back-water pools and the quiet water at the mouths of tributaries where the deep mud affords a rich bottom fauna and where plankton is more abundant.

It is possible that habits similar to those of *Notropis girardi* are practiced by *Notropis longirostris, N. sabinae, N. bairdi,* and *N. dorsalis* since they occupy similar niches in other river systems.

Other species also may employ similar breeding habits. The specimen illustrated in Fig. 4 hatched from an egg taken with those of *N. girardi.*

The longer snout, more oblique mouth, and other characters including general appearance indicate a species other than *N. girardi*—probably *Notropis percobromus* (Cope). The status of *N. percobromus* has been studied recently by Hubbs (1944) who has found it in the Mississippi River as far north as Minnesota. The presence of another species in the screen collections of *girardi* eggs naturally puts some doubt on the identity of the embryos represented in Fig. 1. But since all specimens reared to large juvenile stages were *N. girardi* and since *girardi* is more common than *percobromus* in the Cimarron River, the embryos illustrated have the greatest chance of being *girardi.*

These adaptations supplement those of body form and structure enumerated by Hubbs (1941).

More observations on the time of spawning are needed before a positive correlation between spawning time and river turbidity can be established. Of necessity these observations must await the return of normal economic conditions following wartime restrictions.

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Descriptive Notes on Two Rare Fishes from off the Virginia Capes

By EARL D. REID [1, 2]

MR. Hugh H. Iltis, while a guest of Captain J. W. Quinn on the *Sea Roamer*, obtained on February 11, 1944, a small collection of fishes 80 miles southeast of Cape Henry, Virginia, in the Atlantic Ocean, from a depth of 100 to 150 fathoms. Among these fishes were two rare species: *Priacanthus bonariensis* Cuvier and Valenciennes and *Sphaeroides pachygaster* (Müller and Troschel). The first of these was described from a single specimen, length not stated, forwarded to the authors from Buenos Aires; the second was based on an adult 14 inches long, from Barbados. The Iltis specimen of the latter is much younger, about half the length of the type, but it is unmistakably this species, because of the smooth skin and the position of the dorsal fin which is wholly in advance of the anal. Since both species are new to our fauna and since the latter had not been collected since its original description, it seems advisable to redescribe and figure the two specimens which have been donated to the national collections by Mr. Iltis. The great extension of the known range here recorded adds interest to their rediscovery.

Priacanthus bonariensis Cuvier and Valenciennes

Plate I

Priacanthus bonariensis Cuvier and Valenciennes. Histoire Naturelle Poissons, 3, 1829:105, (Buenos Ayres). Günther, Cat. Fishes in the British Museum, 1, 1859: 216.—Morrison, Proc. Acad. Nat. Sci. Philadelphia, 1889: 163 (based on Günther).

MEASUREMENTS.—The measurements are recorded in millimeters followed by percentage of the standard length in parentheses. Standard length in millimeters, 137, and total length, 170, USNM No. 120996.

Head 44 (32.1); width of head at preopercular margin 24 (17.5); depth of body 61.5 (45); greatest width of body 24 (17.5); eye round, diameter 17.2 (12.6); length of snout 10.7 (7.78); interorbital 15.3 (11.2); length of first dorsal spine 9.2 (6.72) and of last dorsal spine 35 (25.6); longest soft dorsal ray (third) 43.3 (31.8) and of last ray 13.2 (9.64); length of first anal spine 14.7 (10.7) and of third anal spine 30 (21.9); longest soft anal ray (third) 32 (23.4) and of last anal ray 10.6 (7.74); length of pectoral fin 25.2 (18.4); ventral spine 38 (27.8); longest soft ray 61 (44.7); length from tip of snout to rear of maxillary 23.3 (17) and greatest depth 10 (7.3); length of caudal fin 33 (24.1); length of base of dorsal fin 81.5 (59.5); base of anal fin 41.8 (35); length of preopercular spine 6.5 (4.75); tip of snout to origin of dorsal fin 40.7 (29.7); to insertion of ventral fins 50 (36.5); to origin of anal fin 85 (62); least depth of caudal peduncle 15 (11).

DESCRIPTION.—D. X. 12; A. III, 13; P. 18; V. I, 5; scales cycloid 81, 12/40; gill rakers on first arch 5 + 19, gills 4, a slit behind last; pseudobranchiae well developed; profile nearly evenly convex from upper lip to base of last dorsal ray; ventral profile strongly convex from tip of mandible to insertion of ventral fins, then nearly straight to base of first anal ray then oblique to caudal peduncle; mouth very oblique; lower jaw strongly projecting with a broad blunt knob which enters the dorsal profile; mouth moderate, maxillary reaching first third of pupil; eye large, round; length of snout a

[1] Published with the permission of the Secretary of the Smithsonian Institution.
[2] The drawings were made by Mrs. A. M. Awl, artist, United States National Museum.

trifle shorter than postorbital part of head; interorbital convex, a low blunt ridge at midline; preopercle serrate above and below, both margins of equal length, the angle with a strong conical spine reaching beyond the lower posterior edge of the opercle; depth of the cheek equal to length of snout; posterior nostril nearly transverse, somewhat kidney-shaped, its length equal to distance between its outer lower margin and the upper lip; teeth in narrow band on the jaws, vomer and palatines, but no teeth notably enlarged; dorsal fin fitting into a groove, spines graduated to last; the first soft rays of dorsal very high, with posterior margin nearly vertical or nearly truncate, longest rays reaching base of caudal elements when fin is depressed; anal fin similar with 3 graduated spines; ventrals long, reaching to base of third anal ray; ventral spine strong, reaching just beyond anus, and its insertion below the preopercular spine; inner rays of ventral fin attached to abdomen by membrane that extends short distance before anus; caudal fin truncate or very slightly rounded; lateral line not conspicuously arched anteriorly; rising gently from the upper angle of the opercle in a low arch and gradually descending to the midflank under the last dorsal ray, terminating at base of caudal fin; pyloric caeca 7, large; intestine of moderate length with two short loops; air bladder rather large, thin, delicate; body densely scaled everywhere except the lips and fins; the spines and rays of the latter are rough with longitudinal striations and granulations, especially basally.

Color.—Dark grey above, sides silvery, lighter below; tip of lower jaw, snout and predorsal region much darker; membrane of the ventral fins black, the rays silvery; pectoral fins plain; membrane of spinous dorsal black; membrane between the first 4 or 5 dorsal and anal soft rays dark, rest of the fins lighter; tip of caudal fin dark; margin of the scales between vent and anal spines blackish; peritoneum colorless.

Remarks.—Only a single example of this fish was taken. This is the first record of its presence in North Atlantic waters.

This species was synonymized with *Priacanthus boops* (Bloch *in* Schneider) by Devincenzi (Anales del Museo Nacional de Montivideo, ser. II, ent. 5, 1924: 226). I doubt the correctness of this assignment since direct comparison of the present specimen with *Priacanthus boops* USNM No. 75475 from Japan shows a smaller eye, 3 times in distance between insertion of ventral fins and tip of lower jaw, while the eye of the Japanese specimen is contained 2½ times in this distance. The preopercular spine in the Atlantic fish is nearly conical, long, and reaches well beyond the margin of the gill cover, while in the Japanese example the spine is compressed or flat, nearly triangular, with a broad base, and does not reach the margin of the gill cover.

The Priacanthidae have at least four distinct types of squamation so differing as to suggest that at least four genera should be recognized. Likewise, the form of the vertical fins probably would be considered of generic value. Owing to the limited material available, I consider it inadvisable to set up additional genera for this group at present.

Sphaeroides pachygaster (Müller and Troschel)

Plate II

Tetrodon (*Cheilichthys*) *pachygaster* Müller and Troschel *in* Schomburgk, Hist. Barbados, 1848: 677 (Barbados).

Tetrodon pachygaster Günther, Catalogue of the Fishes in the British Museum, 8, 1879: 287 (Barbados); after Müller and Troschel.

Sphaeroides pachygaster Jordan and Edwards, Proc. U. S. National Museum, 9, 1886: 235 (Barbados; after Günther).

Spheroides pachygaster Jordan and Evermann, Bull. 47, U. S. National Museum, pt. 2, 1898: 1738 (Barbados) (Günther).

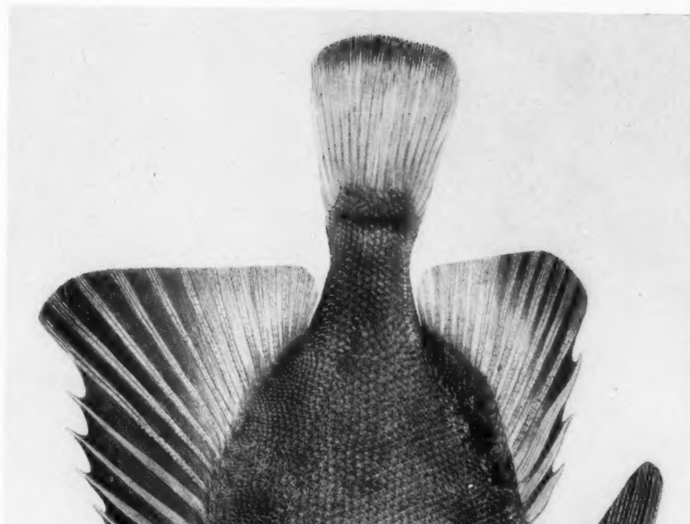

Plate 1. *Priacanthus bonariensis* Cuvier and Valenciennes. USNM No. 120996. Standard length 137 mm.

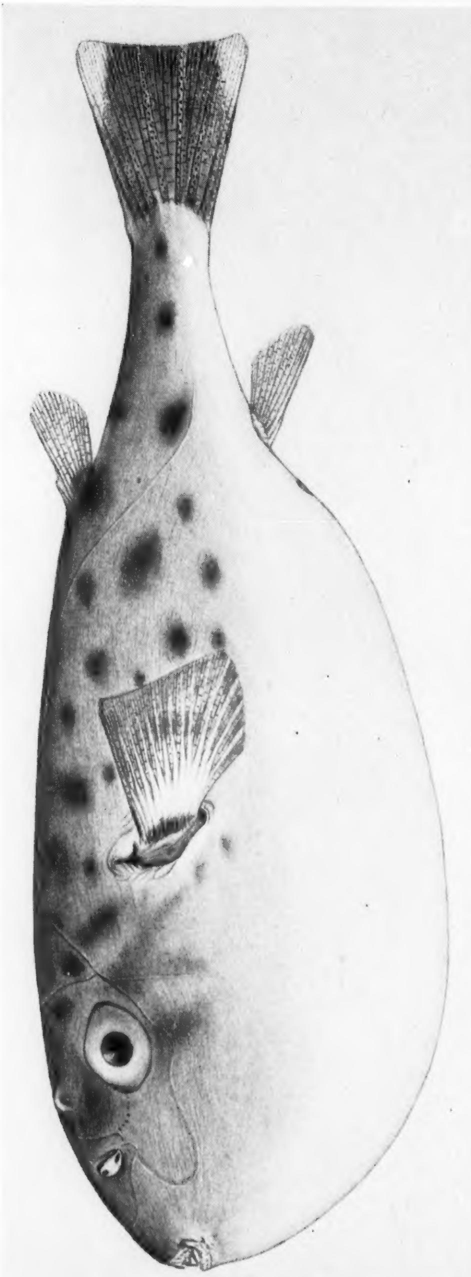

Plate II. *Sphaeroides pachygaster* (Müller and Troschel). USNM No. 121952. Standard length 160 mm.

Cheilichthys pachygaster Jordan, Evermann and Clark, Rept. U. S. Comm. Fish., App., pt. II, 1930: 499 (Barbados).

MEASUREMENTS.—The measurements are recorded in millimeters followed by percentage of the standard length in parentheses. Standard length 160, total length 188, USNM No. 121952.

Head 61 (38.1); depth 60 (37.5); width at base of pectoral fins 43 (26.9); horizontal diameter of eye 13 (8.12), vertical diameter 9 (5.62); length of snout 30 (18.8); bony interorbital 17 (10.6); tip of snout to origin of dorsal fin 115 (71.9); tip of snout to origin of anal fin 128 (80); length caudal peduncle 33 (20.6); depth of peduncle 11 (6.88); height dorsal fin 17 (10.6), anal fin 17 (10.6); length caudal fin 28 (17.5); distance between nasal openings 15.4 (9.62); length nasal opening 5.5 (3.44); pectoral fin length 19 (11.9).

DESCRIPTION.—D. 9; A. 9; P. 18. Body smooth, without spines or prickles anywhere, the skin loose and movable, that of belly somewhat puckered or wrinkled; bases of fins submerged in their sockets, giving the general appearance that the fish is exceedingly fat; dorsal profile very slightly convex from upper lip to nostrils, then more convex to the occiput, and then very little curved to base of the caudal fin; convexity of the ventral outline much more pronounced; lips with about five folds of skin supporting short fringes; nostrils with two openings, each tube short and thick, situated in a transversely large oval opening; eyes oval, about ¼ longer than deep; interorbital broad, flat, two bony projections under the skin above and before eyes caused by lateral expansion of the frontals; the dorsal region is flattish, transversely from the nape nearly to origin of dorsal fin; dorsal inserted an eye diameter nearer tip of tail than posterior rim of the eye, the hind margin of the fin a little rounded; anal similar, of equal height and shape, its insertion much farther back, wholly behind base of the last dorsal ray; pectorals not very large, width of their bases about equal to diameter of the eye; posterior margin of the fin with the upper half concave, the lower half convex; caudal fin truncate when spread though when closed the middle rays are distinctly shorter than the outer ones. Gill openings about equal to greatest diameter of the eye.

COLOR.—Very dark grey above, lighter on the flank, white on the belly; several large black spots scattered over the back and sides, the largest one on the flank just before dorsal fin, one at base of fin extending short distance on rays, one near tip of pectoral fin, and about two very irregular rows along flank to above anal fin; all of these spots indefinitely placed, their positions on the two sides not agreeing; base of the pectorals black followed by light area, the posterior half of the fin grayish; dorsal about the same color; anal white, somewhat darker distally; caudal largely dark grey or blackish, posterior half of upper and lower lobes white, the color strongly contrasted.

UNITED STATES NATIONAL MUSEUM, WASHINGTON, D.C.

Morphology of Calcification in *Squalus acanthias*

By PAUL BENZER

INTRODUCTION

THE problems concerning the significance of calcification in the elasmobranchs have resulted in a great deal of discussion in the literature. In essence, the various workers involved were interested in analyzing the histological nature of the calcified cartilage in the group and in determining whether or not it was bone. Kölliker (1864), Hasse (1882), and Roth (1911), all analyzed their material histologically and concluded from their studies that calcified cartilage in the elasmobranchs is not bone. Stark

(1844), on the other hand, made chemical analyses of calcified cartilage from which he concluded that the chemical residues obtained were almost in the same proportions as in bone. Goette (1878) also proposed the fact that bone exists in the sharks and rays, and attempted to make his hypothesis tenable on a phylogenetic basis. He said that the endoskeleton as a system passes through numerous stages in its phylogenetic development to true bone, and that calcified cartilage of the elasmobranch is bone to some degree.

Röse (1898) and Tomes (1898 and 1914) did detailed studies on the description and classification of the varieties of dentine in the elasmobranchs. In their descriptions of the dentinal structures neither went further than to present a study of each specific type.

The present paper is concerned with an attempt to determine the degree of calcification, time and place of calcification, and whether or not it partakes in the developmental growth of the animal. Incidental data are also presented in this brief paper on the origin and development of vaso-dentine in the teeth of *Squalus acanthias.*

Materials and Methods

In these studies *Squalus acanthias* (spiny dogfish) was chosen because of its easy availability. The specimens were obtained through the Marine Biological Supply Company at Woods Hole.[1] It was necessary to use specimens preserved in alcohol rather than formalin, due to the decalcifying properties of the latter. There were about seventy-five fish in the lot, ranging from 13 cm. to 16 cm. embryos to 60 cm. and 90 cm. adults. Numerous preparations were made of specimens of the same size, in order to obtain some information concerning the variation in calcification of cartilage in the size studied.

All of the specimens were cleared with 2% potassium hydroxide. The calcium deposits were stained specifically with sodium alizarine monosulfonate (Alizarine Red S) and the specimens were mounted in 100% glycerine. A bleach of one drop hydrogen peroxide to every 10 cc. of potassium hydroxide was used to hasten the preparations according to the method and modifications described by Benzer (1940). The teeth in this study were stripped from the jaws of a number of dogfish of various sizes. It was possible to strip all the teeth from one jaw as a unit because of their method of attachment by a layer of fibrous connective tissue. Each strip, therefore, had on it teeth that ranged from flabby tooth buds to partially and fully matured teeth. Upon complete preparation, the teeth were mounted in Euparal Vert and the structure of the whole tooth was studied without sectioning or grinding. The large fish were eviscerated to facilitate a more rapid preparation. Although in these preparations the tissue is transparent, it remains tough enough for dissection in localized areas without distorting the material.

Observations

Calcium deposition was not complete on any of the cartilage on which it was found. Its early appearance was detected in the form of localized, minute, fiber-like depositions. As the animal developed, and calcification

[1] Much appreciation goes to Dr. Leonard P. Sayles of the College of the City of New York for assisting in obtaining the original material.

continued, the deposits took on and maintained the pattern of hexagonal plates (Fig. 1). Throughout the life of the fish the calcification of the cartilages is purely peripheral, except in the vertebrae, in which the initial deposits are surrounded by the developing centrum and trapped within the cartilage. This development will be described below in the text.

Though a large percentage of the material was embryonic, chondrification of the various portions of the endoskeleton is fairly well advanced before calcification makes its appearance. Examining the endoskeleton as a whole, the first cartilages to calcify are those of the visceral arches. These soon bear teeth upon them which also calcify. Calcification immediately follows in the skull, simultaneously with the vertebrae, and last the girdles and appendages.

Of the visceral cartilages, embryos of 13 cm. show the first signs of calcification in deposits both upon Meckel's cartilage and palatoquadrate, with faint stippling on the basihyal. Calcification of the basihyal spreading to the ceratohyal follows in the 17 cm. embryo. Dense deposits are noted on the median piece in embryos of 20 cm. At this stage, light, but definite, deposits are forming on the hypobranchials and the ceratobranchials. These general patterns continue throughout the visceral arches as the animal grows.

The teeth begin to develop in the 13 cm. embryo. As the animal grows, this primary set of teeth is further developed, calcified, and differentiated until the embryo becomes free swimming (at about 25 cm.). During this period the teeth have the general shapes and structures of pulp, primary dentine, and enamel (or vitrio-dentine) that are in the teeth of the adults—except the highly developed layer of vaso-dentine. The development of the tooth structures up to this stage seems to be primary only; and not until they have matured functionally, such as when they reach the outer edges of the jaw and are actually utilized as teeth in an animal able to eat, does a secondary or further differentiation ensue, which leads to the development of a vaso-dentine.

Because the teeth of the elasmobranchs are typically lyodont (i.e., the oldest row is replaced by the one behind as the teeth are shed), it was of much advantage to maintain all the teeth on a single jaw as they were, embedded in a strip of connective tissue. Although it is hard to tell when the casting off of the teeth begins, one may assume that it is probably when the young fish of about 30 cm. loses its yolk sac and begins depending on its predaceous habit of obtaining food. This assumption is based on the fact that it is in the 30 cm. pup that the development of the vaso-dentine begins in the older teeth immediately prior to their replacement.

Of the usual five or six rows of teeth found on the jaws of a dogfish, three tooth types can be chosen to illustrate fully the steps in the advancement of the vaso-dentine. The first type comprises the newly developing teeth which are not yet fully calcified and are still partially covered by a fold or flap of the mucous membrane. They are newly erupted from their tooth buds and lie on the inner-most part of the jaw. The main features of this type are a minimum of calcification and a distinguishable series of enamel, dentine, and pulp layers. The second type comprises the fully developed teeth, not yet in full use and located along the inner part of the jaw. At this stage, the contrast of the heavy enamel coat upon the equally

thick layer of primary dentine to the comparatively immense pulp is readily seen (Fig. 2). The dentine here is clear and somewhat free from an excessive vascularity, with only a few dichotomous tubes arising from the pulp and being dispersed therein. Between this stage and a stage of an aged or shed tooth, the actual development of the typical vaso-dentine takes place (Fig. 3). As the dentine is produced, the pulp undergoes a regression, leaving the evidence of its presence in the numerous ramifying dentinal tubes (Fig. 4). The final stage in the development of the vaso-dentine, therefore, is found in the oldest of the tooth rows on the outermost border of the jaws (the third of the three types referred to above). Most of the teeth in the outermost rows are, in general, of identical structure, being characterized by an enamel cap over a thick layer of dentine which is invaded by numerous tubular elements arising from the now receded and constricted pulp. In all the pulp is persistent to some extent.

The cartilages of the skull are next to calcify. Centers of calcification may be seen in the skull as early as in the 15 cm. embryo. In an embryo of 15 cm. two initial centers appear on the ventral surface of the skull immediately anterior to the occipital condoyles and paralleling each other medially. At this stage, a relation may be seen between the intial areas of calcification and the primordia of chondrification, for, according to de Beer (1937), in the early embryonic development of the chondrocranium, the paired parachordal cartilages are primordia of the skull and develop in this same region. These two centers of calcification develop cranially to the internal carotid foramen; laterally, they extend toward the posterior-ventral border of the skull; and medially up to and paralleling the cranial notochord. These centers fuse in the 23 cm. embryo.

Appearing irregularly between the 15 cm. and 20 cm. stages, another series of paired centers begins to form near the medial part of the preorbital process on the ventral surface of the skull. Posterior to the above two centers in the narrow area on the ventral border of the orbits, are two other centers of calcification. Later in development (at the 24 cm. size), the anterior and posterior centers on the ventral border of the orbits fuse with each other to form two elongated calcified rods. These centers of calcification may be compared to early centers of chondrification; for de Beer (1937) describes the trabeculae cranii as forming the second significant pair of

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Plate I

Fig. 1. Photomicrograph of calcified cartilage showing the hexagonal plate-like nature of the calcium depositions (about 160x). Fig. 2. Rapidly developing tooth showing very large pulp (about 18x). Fig. 3. Matured tooth showing the immense area of the newly developed vaso-dentine and the ever present though diminishing multilobed pulp (about 18x). Fig. 4. Enlarged view of the pulp, dentine, and enamel layers in a fully matured tooth (64x). Fig. 5. Diagramatic view of ventral skull in 23 cm. specimen showing the initial centers of calcification. (Key—1, Parachordal-like centers of calcification. 2, Trabaculae-like centers of calcification. 3, Hypophysial-like center of calcification. 4, Initial auditory chain elements of calcification). Fig. 6. Diagramatic view of ventral skull in 25 cm. specimen showing the early fusion of the various centers. (Key—1, Fusion of parachordal-like region with that of auditory chain and hypophysial crescent. 2, Sheets of calcification forming in the early trabaculae cranii region. 3, Progressive calcification of auditory capsule. 4, Calcification of pre-orbital process. 5, Calcification of post-orbital process.)

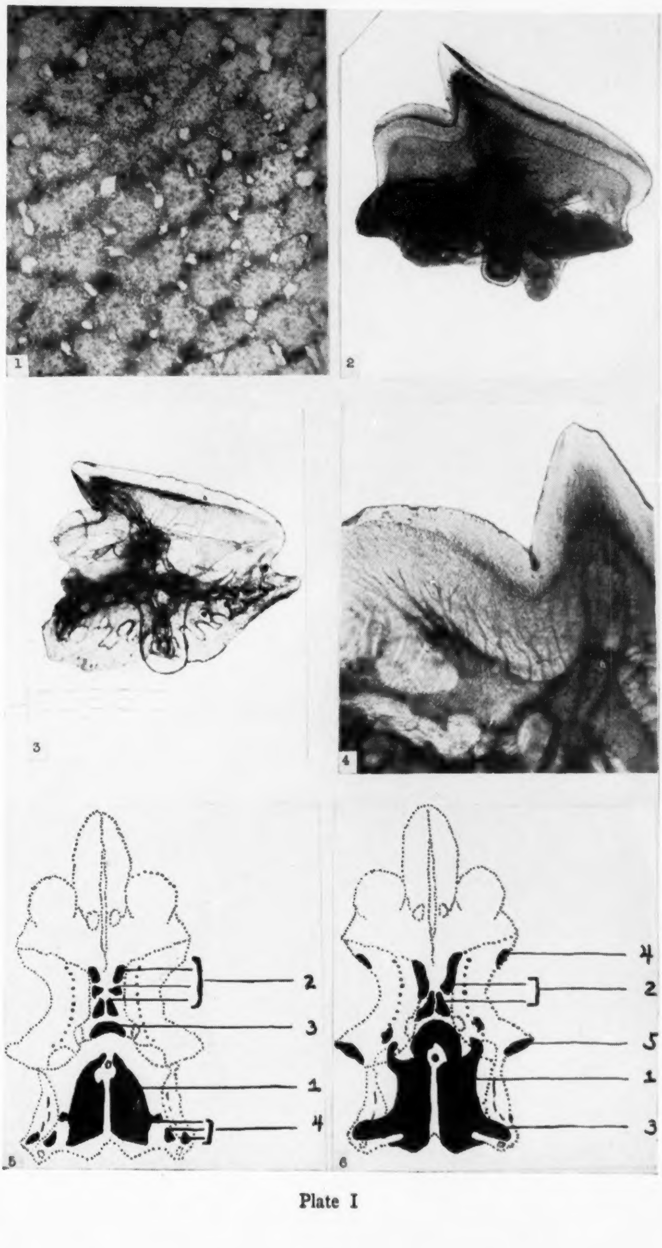

Plate I

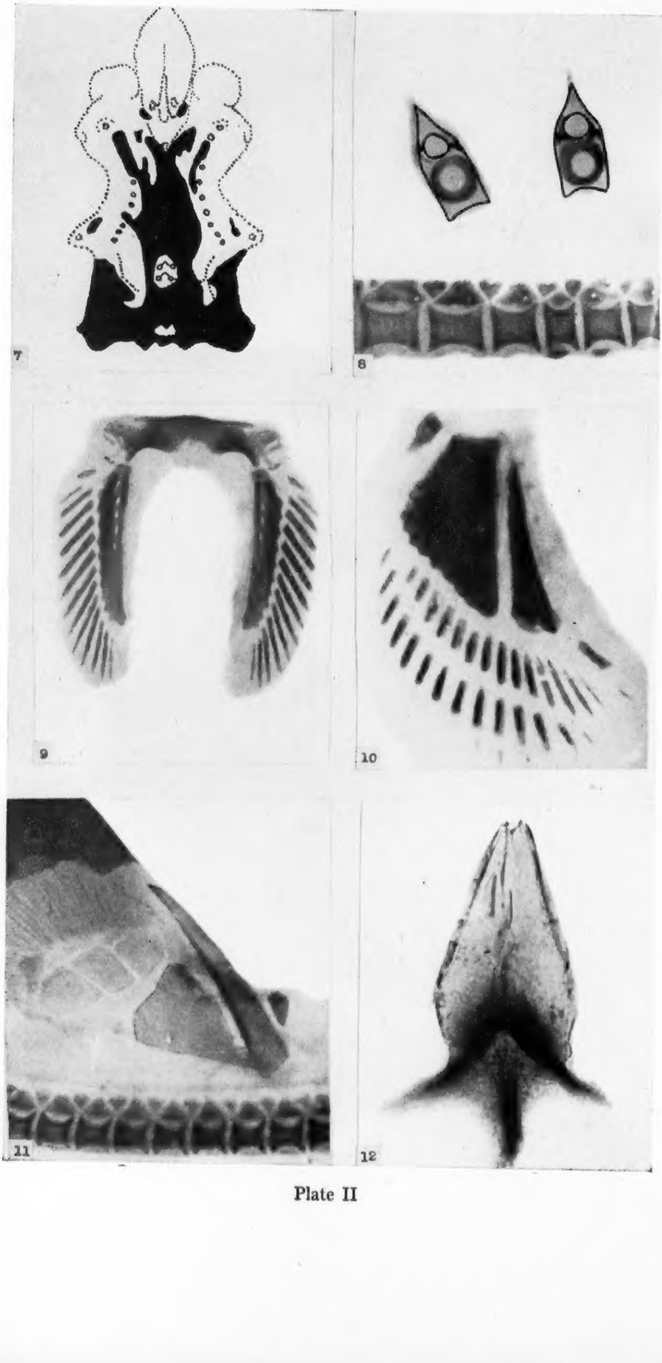

Plate II

primordia in the development of the chondrocranium in this region. In the 20 cm. embryo, on the posterior end of the narrow area between the orbits and anterior to the palato-basal articular process, two small calcified rods are seen as centers, while extending between and slightly posterior to the basilar process, is a single crescent-shaped center. Again, a comparison may be made between these early centers of calcifiation and early primordia of the chondrocranium, since de Beer (1937) cites the development of a hypophysial cartilage in the early chondrocranium, developing ventrad to the pituitary body as a primary center in this region.

In an embryo of 23 cm., all of the above mentioned centers of the skull are present as individual unfused units, and the chief development up to this stage is their appearance and apparent growth, with no noticeable fusion (Fig. 5). Furthermore, multiple calcified centers are developed about the area of the auditory capsule. Posteriorly, each of the calcified centers in the region of the old parachordals gives off a process which grows toward the auditory capsule. Somewhat anteriad to the glossopharyngial foramen on the crest between the ventral and lateral portions of the skull, are two other centers, whose configuration seems to encircle the otic capsule in a chain-like fashion (see Fig. 5). De Beer (1937) lists two independent centers of chondrification in the formation of the auditory capsule, resulting in the fusion of the anteriolateral and posterior cartilages.

In the 21 cm. embryo, calcification makes its appearance on the ventral surface of the postorbital processes. While up to this point the dorsal areas have been free of calcification, now three small spots appear in the center of the tegmen cranii placed so as to form the corners of a triangle. Material preceding the 23 cm. stage is embryonic, and no fusion takes place until the 25 cm. size, at which time the pups are free-swimming. The spread of calcification is then quite rapid, and almost immediately, fusions of the primary centers and full depositions over the surface of the skull become complete (in about the 30 cm. pup).

During this rapid growth, the two centers comparable to the parachordals are the first to fuse, joining each other at their anterior ends, and then fusing with the posterior portions of the crescent-shaped center that had been compared to the hypophysial cartilage which lies between the palato-basal articular processes. The spread of the calcification diverges away from all sides of the internal carotid foramen, and the parachordal-like centers do not fuse with each other along the cranial notochord until all the other centers of calcification in the skull are well fused (Fig. 6). The centers about the auditory capsule unite and form a sheet extending from the

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Plate II

Fig. 7. Diagramatic view of dorsal skull in 32 cm. pup, showing calcification of its different regions; see text. Fig. 8. Lateral and cross section views of vertebrae from a 25 cm. pup. Cross sections show an invasion of the inner wall of the Haemal spine by way of the continuous cartilage through the spinal nerve foramina. Fig. 9. Photograph of the pelvic girdle of a 30 cm. pup showing its regions of calcification. Fig. 10. Photograph of a pectoral fin of 75 cm. fish showing distal spread of calcification to the radials. Fig. 11. Photograph of a dorsal fin of a 75 cm. fish showing calcification in the base of the spine and the large basal cartilage posterior to it. This specimen shows a small cartilage anterior to the spine which is calcified. This cartilage is not found in the other specimens. Fig. 12. Photomicrograph of a placoid scale (about 160x).

glossopharyngeal foramen to the middle of the parachordal-like plates. The centers between the optic capsules fuse with each other in pups between 20 cm. and 23 cm. in length. Calcification is now present on the preorbital as well as on the postorbital processes (Fig. 6).

The first centers on the tegmen cranii are joined by a rapid spread of calcification from the ventral skull through the opthalmic nerve foramina to the epiphysial foramen. Simultaneously there is an invasion of the posterior part of the dorsal skull by way of the ventral deposits coming up, on, and over the auditory capsules and the occipital crest (Fig. 7). The dorsal and ventral surfaces of the superorbital crest are calcified by a spreading of the two centers that were formed at the preorbital and postorbital processes respectively. The deposits of calcium salts thicken on both the outer and inner surfaces of the cartilages as the development continues throughout the life of the animal. In the largest specimen studied, an adult 90 cm. in length, the chondrified structure of the skull was not in its entirety calcified. The regions that remained uncalcified were all of the rostrum, except the lateral surfaces of the palato-basal articular processes.

The vertebrae show their first signs of calcification in the 16 cm. embryo, in which pairs of calcified arches may be distinguished in the dorsal and ventral regions of the centrum of the trunk vertebrae. These early centers of calcification in the vertebrae are comparable to the centers in the early development of the cartilaginous vertebrae. Wurmbach (1932) states that definite paired cartilages form around the notochord, fusing later above and below to make the centrum. These are known as the arcualia in the early chondrification of the vertebrae. In the 17 cm. specimen the calcified arches fuse.

The cartilaginous structures of the vertebrae are not complete, and therefore, when they do unite, they do so over areas of calcification, thereby trapping depositions of calcium within the cartilage. At this stage, the inner as well as the outer surfaces of the centrum are calcified both in the trunk and tail vertebrae. In a 25 cm. specimen the haemal and neural spines show calcium deposits and there is an invasion of the internal cartilaginous walls of the respective canals by way of the continuous cartilage through the spinal nerve foramina (Fig. 8). The intercalary plates are also slightly calcified at this stage. After 25 cm. material, other than the calcifiation of the ribs, no further developments in the vertebral column are noted. Thickenings in the calcium depositions do take place.

The coracoid bar and the ischopubic bar are the first elements of the girdles to calcify; this occurs in the 16 cm. stage. In the 20 cm. embryo, faint calcification is noted on the mesopterygium, metapterygium, and propterygium of the anterior fins while the basipterygia of the pelvic fin are also calcifying. Further calcification of the paired fins spreads to the basals and several of the radials in adult fish but go no further (Figs. 9 and 10). Both dorsal fins show early signs of calcification in the fin spines, the bases of which represent basal cartilages of the fins. They become calcified very early in the 16 cm. specimens. The large triangular basal cartilage immediately posterior to the basal of the spine is the only other cartilage to calcify in these fins and it does so at the 20 cm. size (Fig. 11). The actinotrichia do not calcify in any of the fins.

During the course of the studies, beginning with the 13 cm. embryo, many beautifully prepared placoid scales constantly came under observation. They varied in shape depending on what part of the body they came from, but in all, their internal structures were basically alike (Fig. 12).

Discussion

The appearance of the centers of calcification on the various parts of the endoskeleton as described for *Squalus acanthias* in the foregoing material is of interest. Contrary to the commonly held belief as implied by Daniel (1934) and other workers, that calcification in the Selachii and Batoidei consists merely of a deposition of diverse and curious designs, an examination of the material on hand shows that in the location of its initial centers, in its patterns, and in its symmetrical distributional growth, it is quite stereotyped—at least in *Squalus acanthias*. There also seems to be a specific relationship between the early centers of calcification and the early centers of chondrification, particularly in the skull and vertebrae.

Summary

(1) A study was made to determine the patterns and progressive development of calcification in *Squalus acanthias*. Specimens were prepared by clearing in potassium hydroxide and staining the calcium deposits specifically with sodium alizarin monosulfonate (Alizarin Red S).

(2) Calcification was found to be peripherial in its depositions except in the vertebrae, in which it was surrounded and trapped within the cartilage.

(3) Initial centers of calcification developed similar to the centers of chondrification of the endoskeleton.

(4) Calcification is not random; it does not merely form diverse and curious designs as has been commonly supposed, but, at least in *Squalus acanthias,* follows a specific and constant pattern.

(5) Teeth of *Squalus acanthias* were studied to trace the development of the vaso-dentine.

(6) The teeth do not become functionally mature until the animal absorbs its yolk and begins to depend upon its predaceous habit in getting food.

(7) In the life history of the dogfish teeth, there is a conventional method by which the vaso-dentine develops. The pulp starts large and gets smaller as the teeth mature, trapping the dentinal tubules within a dentine matrix.

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Notes on the Eggs and Larvae of *Aneides lugubris*

By Loye Miller

At the close of the past century the present writer collaborated with the late William E. Ritter in a paper on *Aneides lugubris* (1899) and Ritter later (1903) published a second note on the species. But there remained much to be learned, especially as regards the early stages of development. My own study of the species was continued during a year's residence in Berkeley in 1903–4, but attention was necessarily shifted with change of location and duties.

During the four decades that have followed, there has not come to my attention any extended study of the species. My notes on habits and distribution were placed at the disposal of Dr. Tracey I. Storer and excerpts were published in his general paper on the *Amphibia of California* (1925). There remain some unpublished notes and drawings of life history stages. An attempt was also made to adjust individuals to an aquatic life by excising the embryos from the capsule at the time of maximum gill development and placing them in natural water. The results of these experiments, though admittedly incomplete, are here placed on record, together with my drawings [1] and a review of the life history.

The literature dealing with the species is not extensive and it is somewhat scattered, hence a measure of re-statement is perhaps warranted by the unique position that this highly specialized amphibian holds in biology.

[1] All drawings, except Figure 4A, were made by the author.

1. The adult animal is entirely lungless, the pulmonary artery passing backward to apply itself to the wall of the stomach.
2. Respiration is accomplished in part through the lining of the mouth and pharynx, which is ventilated by rapid palpitations of the floor of the mouth. Much of the respiration is also accomplished through the general body covering. The microscope focused anywhere on the dorsum will show blood corpuscles tumbling through the capillaries. The expanded ends of fingers and toes are provided with enlarged blood sinuses where aeration is probably especially effective.

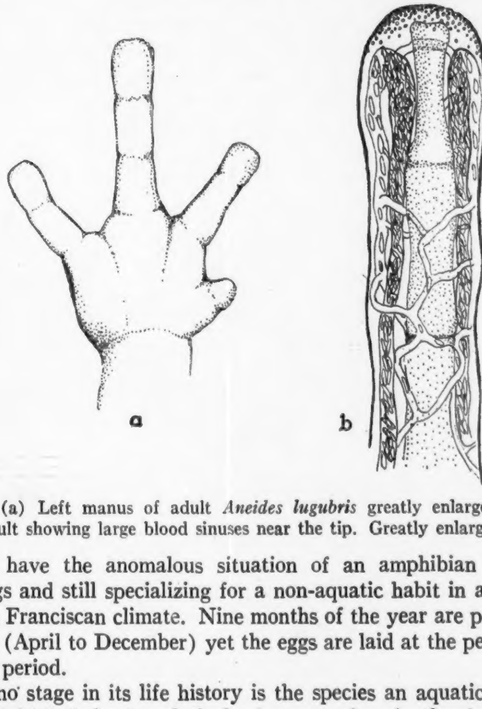

Fig. 1. (a) Left manus of adult *Aneides lugubris* greatly enlarged. (b) Digit of manus of adult showing large blood sinuses near the tip. Greatly enlarged.

3. We have the anomalous situation of an amphibian discarding its lungs and still specializing for a non-aquatic habit in an area subject to a Franciscan climate. Nine months of the year are practically rainless (April to December) yet the eggs are laid at the peak of the rainless period.
4. At no stage in its life history is the species an aquatic animal. Eggs are laid in holes in relatively dry ground or in the decay cavities in oak trees sometimes as much as 30 feet from the ground. Dessication of the eggs is seemingly prevented by contact with the body of the attendant parent supplemented possibly by voidings from the urinary bladder.
5. Elimination of the larval stage is correlated with a great increase in size of the egg which has the external appearance of a meroblastic type of cleavage. Very early stages have not yet been seen.
6. Adult animals are nocturnal and during the dry season, their activities are somewhat reduced. However, in the humid coastal area of California a certain amount of moisture is available at night from dew or

fog laden vegetation. This permits a measure of nocturnal activity even in the non-rainy season. In the decay cavities of oak trees there is a considerable amount of live fungus and wood detritus which furnish a humid environment.

7. Food of the adults is possibly supplied in part by this fungus. Its spores are recognizable in feces of freshly captured animals. Other items of food that have been recognized are insects and myriapods, and one small salamander (*Batrachoseps*).
8. The species is what might be called a "sprightly animal." Its movements are energetic and it may even leap clear of the substrate for short distances. The head may be thrown laterally in a quick movement which suggests a definite use for the elongated caniniform teeth of the upper jaw, which protrude beyond the lips. Scars observed on the bodies of certain adult individuals may easily have resulted from strokes of these tiny sabres wielded by an enemy.

Fig. 2. Cluster of eggs of *Aneides lugubris* found suspended from the roof of decay cavity in live oak tree (× 2).

The animals in captivity seem to have a negative geotropism, which, aided by the expanded terminal phalanges, carries them up the walls of a vivarium. They spend much time at the upper limits of their cages. Night collecting by jack light reveals them on the vertical trunks of trees or on rock walls and it is probably this impulse that leads them to their arboreal hiding places. The climbing habit is probably correlated also with the prehensile power of the tail. This organ is used by laboratory animals to resist being lifted out of the cage, the tail may be hooked over the edge of a dish or about some other object. The animal will hang suspended from the finger by the tightly grasping tail.

9. The species is known from various points west of the Sierran divide in California from Mendocino to San Diego with a subspecies on Farallon Island off San Francisco. Locally the animals are found by day under logs, stones, boards, or other detritus (e. g. nests of wood rats) and in decay cavities of trees as before mentioned. With increasing severity of the dry season, there is probably a retreat into deeper seclusion but a true aestivation comparable to that of the

spade foot toads is not known. In fact this period seems to be at the climax of reproduction, i.e. egg laying.

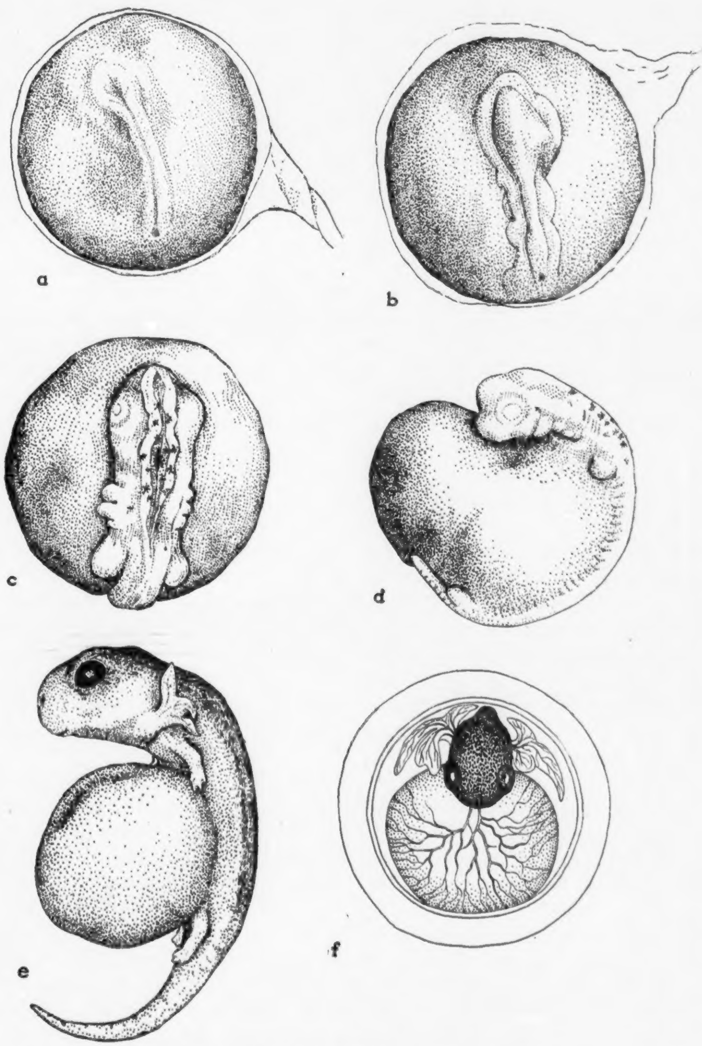

Fig. 3. (a–f) Sequential stages of egg development (× 5–7).

Experiments on embryos in water were conducted with individuals that were excised at the period of maximum gill development as nearly as it

was possible to determine and some two dozen eggs were thus operated upon with success.

The difference in osmotic pressure between water and intracapsular fluid caused an initial opacity and crinkling of the gill margins. This disturbance soon passed, however, and the little animals appeared to be quite comfortable, swimming voluntarily and keeping a good equilibrium.

A sloughing of the skin about the extremities takes place probably owing to the change of fluid medium. Experiments on the viviparous *Salamandra atra* of Europe have been successful in stimulating a permanent gill development and an increase of body length, the young larvae taking food by mouth. The young *Aneides,* however, declined to take food. This was to be expected, since the great yolk mass was not yet absorbed and the ventral abdominal wall still remained incomplete.

After the first "shock" to the delicate gills, the tissues recovered and development seemed to proceed altogether as it would have done in the original egg capsule. The gills remained beautifully transparent and functional. Under the microscope one could easily observe the pulsating surge of corpuscles through the arteries. Metamorphorsis set in at about the same time as it did in the normal siblings. Gills went through size reduction accompanied by an increasing opacity which was initiated at the margins. Blood clots were sometimes observable in the vessels and much regurgitation was seen in the arteries, doubtless due to inability of the closing capillaries to carry the blood through into the veins.

As the gills became opaque knobs on the sides of the neck, some sloughing of their tissues took place instead of complete resorption. This again is probably due to arrested circulation in the periphery. The ventral body wall closed in gradually thus including the yolk mass which was never pedunculate. Metamorphosis proceeded inexorably and the animal drowned.

In only one instance was a temporary adjustment achieved. This animal, No. 6, almost lost out at the crucial point, but unlike all the others, it took up the pharyngeal respiratory movement of the adult and survived for sixteen days after the gills had become reduced to mere scars as in normal metamorphosis.

The adult animals are entirely lungless. Respiration is accomplished in part by rapid pulsations of the pharynx and in part by the entire body covering. For this reason, it was hoped that the animals, if taken from the capsule before the beginning of metamorphosis, could be adapted to underwater respiration. Adults of *Triturus torosus* taken from dry land were plunged into water and prevented from rising to the surface. These salamanders seemed quite comfortable, taking food, sloughing the skin normally and making no attempt to escape during some two weeks duration of the experiment. The adult *Aneides* on the other hand, though so completely equipped with dermal capillaries, will drown, sometimes within a few hours, if plunged into water. The embryos seem almost equally intolerant after they accomplish their metamorphosis.

In several of the experimental embryos one or both of the gills were snipped off at the time of excising from the capsule and immersing in water. But no discernible effect was produced in the progress of metamorphosis. This would indicate that respiration while within the capsule is at least

partially dependent upon the body integument. Why this function becomes inadequate after metamorphosis is indeed a puzzling question. *Aneides,* it

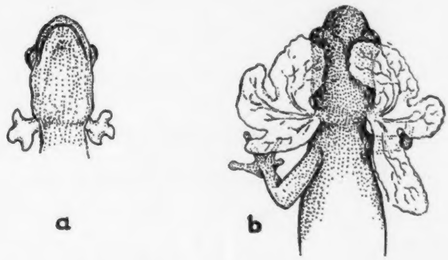

Fig. 4. (a) Young showing gills at hatching (× 2). (b) Excised embryo showing gills at about maximum size. Ten days before hatching (× 2).

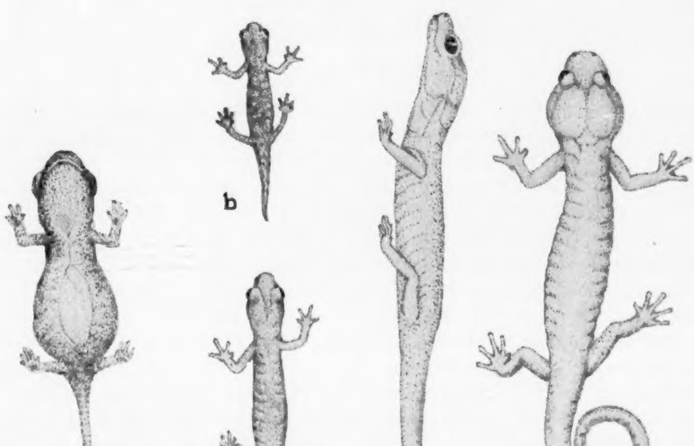

Fig. 5. (a) Young at hatching, gills more reduced than in Fig. 4b; yolk mass visible in median ventral area (× 1⅓). (b) Young of first year—probably 8–10 months old (× ⅔). (c) Young in second year—probably 20–22 months old (× ⅔). (d and e) Adult animals.

seems, is irrevocably committed to the wholly air breathing habit by the phenomenon of metamorphosis.

The temptation to carry on at length regarding my entertaining experi-

ence with these little creatures is really great but the remaining factual material is on record in previous publications.

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Breeding Habits, Eggs, and Tadpoles of *Scaphiopus hurterii*[1]

By Arthur N. Bragg

THE spadefoot toad, *Scaphiopus hurterii,* was first recognized as a distinct species by Strecker (1910) who described and named it from Waco, Texas. It is now known from Oklahoma (Smith and Leonard, 1934; Bragg, 1940a), and Arkansas (Smith, 1937). Quite recently it has been found to occupy the eastern part of Oklahoma in the oak-hickory woodland-savannah and to follow the flood-plains westward into the grasslands on the flood plain forests of the larger rivers (Bragg, 1944). Figure I gives the county distribution as now known. The few notes on the life history of this species by Strecker (1910) and by Smith and Leonard (1934) fail to describe its eggs and tadpoles. I have been on the alert for breeding congresses of this species in Oklahoma for the past several years. Although literally thousands of breeding aggregations of the commoner frogs, toads, and tree-toads of the state, as well as other spadefoots, have been observed, it was not until September 5, 1940, that I found the first such assemblages of this species. These were observed at about 2 A.M., after a heavy rain during the early part of the night; only males were seen and no tadpoles could be found later at either of two locations.

For the spring of 1941, one of the wettest recorded in Oklahoma, I have evidence of eleven breeding congresses of this species between early April and mid-June, all within the eastern half of the state, five of which I know to have produced tadpoles.[2] Each of these occurred after very heavy rains and all appear to have been at night. Breeding activity has been observed between very late dusk and 3 A.M. Observations were made on the breeding behavior in natural pools; on the eggs, tadpoles, and metamorphosis, both in the field and in the laboratory; and on the behavior of adults and of young.

[1] Observations on the Ecology and Natural History of Anura. XIII. Contributions from the Zoological Laboratory of the University of Oklahoma.
[2] Tadpoles (and notes on three breeding congresses) were furnished me by Dr. Albert A. Blair, of Tulsa, Oklahoma. Another congress was reported by Dr. Charles C. Smith.

Scaphiopus hurterii resembles its close relative of the East, *S. holbrookii holbrookii* (Harlan) in breeding at any time during spring or summer when temperature is not too low, but only after heavy rains (Ball, 1936). It is obviously different from the spadefoots of the plains and deserts (*S. bombifrons* Cope, *S. couchii* Baird, and *S. hammondii* Baird) all of which appear to be stimulated more by the *violence* of a storm than by the *amount* of rainfall (see Bragg, 1944; Trowbridge and Trowbridge, 1937; and Bragg and Smith, 1942).

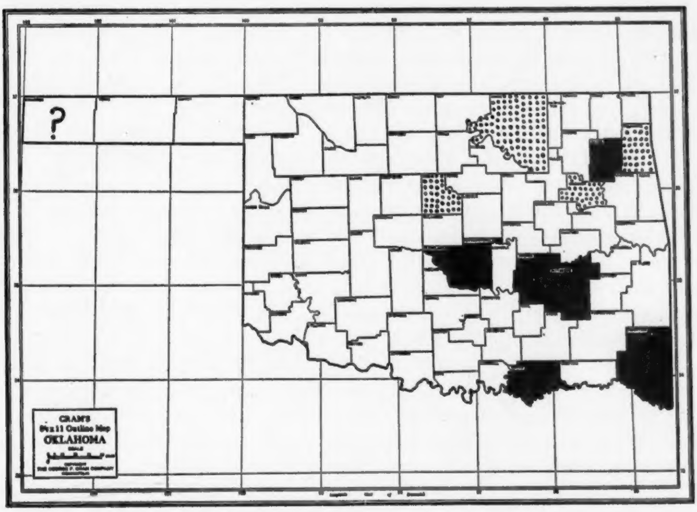

Fig. 1. County distribution of *Scaphiopus hurterii* in Oklahoma as of January 1, 1943. Solid black, specimens examined; heavy stipple, calls reported by A. P. Blair or Charles C. Smith; ?, record of *S. holbrookii holbrookii*, probably referable to *hurterii*.

Breeding Behavior

Scaphiopus hurterii, like other species of spadefoots whose habits are known, utilizes temporary pools for breeding, such as shallow roadside ditches and the extensive muddy pools in the woodland, 3 to 3½ feet in depth. In one location these spadefoots bred three times during the season in a large shallow pool (described below), while none were calling from a larger, deeper pool within sight of the first one, not more than 100 yards distant; nor could I later find tadpoles in the deeper pool.

Males call from various places in and about a pool, at the bank, in the very edge of the pool, and more commonly from the surface, sprawled out in the manner typical of other spadefoots.

The call is a single note, which, while guttural, has a peculiar soft quality not unpleasing to the human ear, quite different from that of *Scaphiopus bombifrons, S. couchii,* or *S. hammondii* and different also from descriptions of the cry of *S. h. holbrookii,* which is commonly stated to be very harsh and loud (cf. Ball, 1936). Nevertheless the voice of *hurterii* has a quality characteristic of spadefoot breeding calls; I recognized it at once when first heard as

a spadefoot call. The cry is not exceptionally loud, although a large chorus can be heard for at least one-half mile. (I have heard *S. bombifrons* for more than 2 miles on a still prairie night.) The calls of males tend to stimulate other males to call and to attract both females and other males to a given pool (Bragg, 1944).

Each call is explosively given, and the vocal sac becomes fully distended and then deflated each time. Intervals between calls vary, both with the numbers of individuals present and with numbers calling at any one time. The usual interval in a large, excited congress is from one to two and one-half seconds. There is no tendency for the calls of males to be synchronous.

The behavior of males varies with the calling station. Those at or near the bank move very little between calls. Those on the water swim about actively, especially when other individuals are nearby. Their interactions at such times suggest strongly the behavior of males of *S. hammondii* (Bragg: 1941) in that they swim toward each other, paw at one another, and otherwise act as though attempting to secure a mate. When one male is clasped by another, he immediately utters a cry, whereupon he is quickly released. This behavior suggests that males search for females while swimming and calling at the surface and that sex recognition is mostly a matter of voice. Females have been seen both on the bank and on the surface with the males, but mating in the field has not been observed. In artificially mated pairs, the clasp is inguinal as in other spadefoots.

Specimens of either sex and at all ages, whether about a breeding pool or not, remain absolutely still when a flash-light is played upon them while on land at night. At such times, they can be picked up like so many stones. In water, however, they commonly react by slowly sinking beneath the surface, swimming for a short distance, and then emerging at another part of the pool. If greatly frightened, they tend to remain on the bottom for some minutes. On the other hand, if stimulated by a great many calling males in a pool, they may pay little or no attention to human beings. In these respects they closely resemble other spadefoots.

Eggs and Egg Masses

All masses of eggs of *S. hurterii* seen were produced near the shore, at and near the water surface, and strung out over vegetation. When in place, they superficially resemble those of *Bufo* rather than those of other spadefoots. Each egg is black at the animal pole, shading to very light grey or white at the vegetal. Each is inclosed in a ball of jelly considerably larger than itself, i.e. in a single, thick, gelatinous envelope. Individual eggs vary little in size, each being about 2.3 mm. in diameter. The gelatinous capsules also are quite uniform at about 6.7 mm. The gelatinous coats are elastic and quite sticky so that they easily pick up particles from the surrounding water. This tends to conceal them after a few hours. The little gelatinous balls tend to stick together in various patterns. These patterns are quite irregular, but most often the eggs attach tandem-fashion so that an irregular string is produced with some similarity to the eggs of toads (Fig. 2). There is no continuous, gelatinous, encasing tube as in *Bufo,* and one egg within its covering can easily be separated from others to which it is joined. Such strings may be very short or several inches long. Individual eggs of one such string com-

monly attach to others in adjacent strings, forming a network. Several such lattices are sometimes similarly joined to form a three-dimensional pattern. A winding string of eggs, loosely attached to other such strings wherever contact happens to be made between them, is mostly commonly found.

The number of eggs in a complete clutch is unknown, but the complement must consist of several hundred at least.

Development and Hatching

No attempt has been made to follow the embryological development in detail. The rate of development is rapid. Eggs laid during the night of April 14 hatched in the pool on the 16th. At another time, eggs reached the gastrula stage in just over 24 hours and hatched in another day at room temperatures in the laboratory. Some of this second lot, kept at 2° to 3° C. above room temperature, hatched from seven to eight hours earlier. At the gastrula stage, the embryo lies in a cavity just larger than itself, the wall of which is a very thin membrane, the so-called chorion. As development progresses, this cavity increases at a greater rate than the embryo so that, at the early tail-bud stage, the embryo lies in a bubble of fluid whose diameter about equals the length of the embryo. This bubble is still encased in the gelatinous coat. At hatching the larva must emerge through the two membranes.

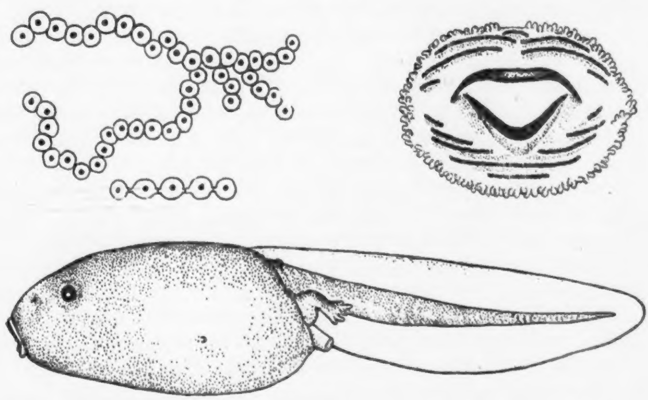

Fig. 2. Eggs, mature tadpole and tadpole mouthparts of *Scaphiopus hurterii*.

The late embryo presents a characteristic appearance. It is short, thick and stubby, and black above and on the sides, shading to a dark grey below. The eyes are very large but still undeveloped. There is a high but rather fleshy ridge down the dorsal midline that flares to a large knob at the tail bud. Just before hatching, the embryo has become very slightly curved within its cavity but never so much so as in the common frogs and toads. At this time, the gelatinous capsules average about 1 mm. more in diameter than at the gastrula stage. This seems to be the result of the stretching of the elastic jelly by the increase in diameter of the chorionic cavity in which the embryo lies. The embryo at this time measures about 6 or 7 mm. in length and is ciliated dorsally and laterally.

The process of hatching is not at all like that observed in *S. bombifrons*. Instead, it closely resembles the process in *Bufo w. woodhousii* as recently described by myself (Bragg, 1940, 1940b). An hour or more before hatching, the embryo begins a slow rotation, due to ciliary action, with the head and tail-bud pressed against the chorion. During this time the gelatinous envelope appears to become softer and to have a thinner consistency. Eventually, a large opening breaks through it and the pressure produced by the increasing volume of liquid accumulating inside the chorion gradually forces out the bubble containing the embryo. Rotation of the embryo within the freed bubble continues for a half hour or so. At the end of this period, wrinkles suddenly appear in the chorion near the head of the animal, the membrane bulges at the head forming an out-pocketing, the head of the embryo slips into this evagination, and the embryo straightens as the whole bubble changes in shape from spherical to ovoid. A few seconds later, the head breaks through the membrane and the larva slides into the surrounding medium by ciliary propulsion.

Although slight muscular twitchings may be seen prior to hatching, muscular movements are not used in hatching. This species, therefore, belongs to the group the members of which hatch in a premotile condition.

I have elsewhere suggested that two secretions might be produced by a frontal gland (Noble, 1926) instead of one, the first passing through the chorion without effect upon it to dissolve the jelly, the second later liberating the embryo from the freed bubble. The evidence that this occurs in *S. hurterii* is circumstantial, but strong; for in clear tap water the whole process proceeds as described. It is very unlikely that bacterial action frees the bubble from the jelly. There remain the possibilities that the substance that dissolves the jelly is derived from the embryo, or that the jelly disintegrates automatically within a short time. Since in both *B. w. woodhousii* and *S. hurterii* (the only two species thus far described that hatch in this manner) definite openings are always produced, the former seems the more likely alternative.

It is interesting that the method of hatching of the frogs and toads seems to bear no relation to the taxonomic group to which they belong. Species of *Bufo, Scaphiopus,* etc., differ markedly among themselves. Nor does it bear any relation to the inherent rate of development of the embryo. There is not even a consistent correlation within families: e.g., *Hyla versicolor versicolor* hatches like *Pseudacris streckeri,* a member of the same family, but *Bufo cognatus* varies widely from *B. w. woodhousii,* and *B. a. americanus* is different from either, all members of the same genus. Again, hatching in *Microhyla olivacea* is more like that of *H. v. versicolor* than any other so far observed, although these forms belong to different families, while *Scaphiopus bombifrons* is more like these than like its closer relative, *S. hurterii.*

Description of the Tadpole

At hatching the larvae resemble those of ranas and bufos. They are black, small and undeveloped. The adhesive organ is well-formed and the larvae tend to hang to some object for some time. They do not swim during the first few hours. If they have gills at all, these are mere stubs. Twenty-four hours later they have several pairs of branching gills and feeble swimming has begun. Food is eaten for the first time on the second day after

hatching. With this, they grow rapidly, soon become lighter colored (dark grey instead of black), and take on the "mouse-like" appearance of other *Scaphiopus* tadpoles. No evidence of cannibalism was seen but the larvae attack both plant and animal materials with equal avidity.

The first metamorphosis was noted on May 12, less than a month after the eggs were laid: and all the tadpoles transformed immediately after this date.

The mature tadpoles are small, with very little variation in size. Twenty-three, measured after preservation in 70% alcohol at a stage when the hind limbs were enlarging preparatory to leaving the water, had the following measurements in mm.: mean, head-body length, 10.4 (range 9-12); mean, tail, 12.0 (11-16); mean, total length, 22.4 (21-27). The corresponding means of another group of fifteen were 9.5, 12.0 and 22.5 mm. The greatest variation is in tail-length.

The dorsal ground color is a very dark grey with numerous small, silvery, rounded chromatophores scattered among melanophores. Along each side of the mid-dorsal line the silvery chromatophores are more numerous than elsewhere, thus forming two slightly curved, lighter areas that approach each other (but never touch) about half way between the eyes and the base of the tail. The result gives the appearance, in the dorsal aspect, of a light hour-glass-like area on the back, a very distinctive feature of these tadpoles, persisting in the metamorphosed animals as a forerunner of the light patches on the dorsal surface of the adult.

The ventral ground-color is also grey but is somewhat lighter than the dorsal due to a greater relative number of the silvery chromatophores, here sometimes occurring in groups of sufficient size to give the appearance of faint spotting. Ventral iridescence is slight.

The proportions of the body are such as to make the general appearance relatively elongate. The head is rather narrow, the eyes near together and comparatively small, the nostrils simple openings directly anterior to the eyes at the lateral edges of shield-shaped or roughly triangular areas of slightly heavier pigmentation.

The tail fins are low and of about equal depth above and below. The tail tip is rounded. As the measurements indicate, the tail is a little longer than the head and body. Both dorsal and ventral fins of the tail are clear except that a faint duskiness may develop along the anterior half of the dorsal border of the dorsal fin in some individuals. The dorsal tail-fin reaches the body and extends on to it for a short distance. The ventral fin ends at the posterior edge of the short anal tube, even in very young tadpoles, and this relation persists throughout larval life.

The spiracle is a simple almost circular aperture through the end of a very short spiracular tube opening on the left ventro-lateral surface almost exactly half way between the tip of the snout and the anus. It is directed posteriorly and very slightly ventro-laterally.

The mouth parts vary among individuals. A typical condition is shown in Figure 2. The lips are rather thick and bordered by close-set papillae of nearly uniform size, except for a small space dorsally. Sometimes even this space is absent. The jaws are of characteristic shape, the upper one without a beak, the lower a deep U or open V. Neither jaw is heavily constructed,

the whole apparatus, in fact, having a certain delicacy of form contrasting with that of *S. hammondii.*

The labial teeth vary in both number and arrangement of rows. The most characteristic formulae observed were 4/5 (as figured) and 3/4. The first upper row is sometimes absent; sometimes set more dorsally than shown in the figure so that it actually fills in the space lacking papillae on the dorsal lip. In some individuals (particularly when the first row is absent) the second and third rows of teeth fuse in the mid-line. In a few, the second dorsal row is longer than the third and, if so, the ends bend downward laterally. The first three ventral rows are incomplete. The first is represented by lateral elements of varying lengths. These are usually very short, as shown in the figure, but some individuals have them at least twice as long. The second and third ventral rows are successively longer and set in a more medial position. The fourth ventral row is complete but does not extend so far laterally as any of the rows above it. The fifth ventral row is complete and much shorter than the fourth, varying in length. It is apparently lacking in some individuals, or perhaps lost with approaching metamorphosis.[3]

The structural features of this tadpole add to the evidence that *S. hurterii* is specifically distinct from *S. h. holbrookii* as maintained by Smith (1937) and Tanner (1939). Comparing the description just given with that of the tadpole of *S. h. holbrookii* by Wright (1929) the following differences appear: in *S. hurterii* the jaws are different in shape, the relative lengths and the characteristic numbers of the labial rows of denticles are different, the spiracle differs in position and shape, and the color pattern is different. *S. hurterii* is considerably smaller at metamorphosis than *S. h. holbrookii.* The two forms are alike in variability in the labial teeth, in having a generally similar arrangement of the ventral teeth, and in the general type and arrangement of labial papillae. The differences far outweigh the similarities, but the latter are sufficient to suggest that the two species in question are more closely related phylogenetically than either is to *S. hammondii* or *S. bombifrons.*

Behavior of the Tadpoles and Metamorphosed Young

The majority of the field observations on living tadpoles were made at a single pool in which tadpoles of three different ages were developing, approximately 6 miles east of Norman, Cleveland County, Oklahoma, at the edge of a low valley between two sandstone hills on which the principal vegetation is a growth of small oaks. This is in the western edge of the oak-hickory woodland and savannah (as defined by Bragg and Smith, 1943), which stretches eastward over much of the remainder of the state. The western edge of the mixed-grass prairie lies 2 miles to the west; the soil of the savannah is a red, sandy loam with enough clay in it to allow for some puddling; and water may remain standing for some weeks in depressions after rains, when temperatures are not excessively high.

The *Scaphiopus hurterii* pool is an artificial, crescent-shaped depression (a "borrow-pit"), extending north and south along the gentle slope near the foot of a hill. It measures approximately 105 by 18 ft. and is nowhere more than 2½ feet deep when full. The water is brick red with suspended clay immediately after heavy rains, but, if undisturbed, becomes clear within a

[3] I am indebted to Miss Joni Main, of the Art Institute of Chicago, for the drawings of the tadpole.

month. There are no trees in the immediate vicinity of the pool, which is thus exposed to full sunshine. Some algae grow in the pool but vegetation of other kinds is sparse, even on the muddy slopes leading directly to the water. Grasses and herbs make a light cover farther up the slopes among the clumps of oaks or individual trees. Just northwest of the pool is a small oily seep that allows a dense growth of sedges to form on a small moist area of the hillside. Moisture from this source also tends to accumulate about the bases of oaks below it so that a moist mulch is formed under them by their fallen leaves. The remainder of the environment here is very dry except immediately after rains.

Frequent visits to the pool were made and observations recorded in the field at all hours up to midnight. Hundreds of tadpoles and recently metamorphosed young were collected and studied, both alive and preserved, in the laboratory, throughout the latter half of May and well into June. Later trips in July, August, and September were also made in an attempt to trace the young through their first summer. Prior to metamorphosis the behavior of the tadpoles was that normal to *Scaphiopus*. They swam almost continuously, pausing only when they found food objects. Occasionally, clumps of waving tails announced that the animals had found some large food-mass to which many had been attracted.

The first evidence of metamorphosis is rapid growth of the hind limb-buds, which continues for about a week. Then the forelimbs break through. At about this time, the movements become slower and tadpoles that happen upon others in their random swimming tend to stay with them. These small groups meet other similar groups and all tend to remain together. In the meantime, the movements of individuals, and hence of the compact groups, become slower and more restricted, till at last a dense mass of tadpoles is present on a limited area of the bottom. When I first observed such an aggregation I supposed that it was a reaction to a food-mass, as described above, and I was puzzled that no such object could be found. Further observation proved this phenomenon to be a characteristic social behavior pattern at this stage. Twenty such aggregations were seen within a period of about two weeks, some made up of only a few tadpoles, but many composed of thousands of individuals. Ten aggregations were observed during their formation. Tadpoles in almost all of such aggregations were in active metamorphosis, most of them with all four legs, although a few with three and an occasional one with only two were seen.[4] Each time that a collection from such an aggregation was made, other tadpoles swimming individually in the pool were taken for comparison. Without exception, these non-aggregating individuals were in an earlier stage. Hundreds of tadpoles were examined to prove this point. Tadpoles of other species were also abundant; those of *Bufo a. americanus, Hyla versicolor versicolor, Microhyla olivacea,* and *Pseudacris streckeri* were recognized and none of these aggregated at any time.

The behavior while in these dense schools is characteristic. Each animal moves slowly along the bottom for a few inches, then turns in some other direction so that the whole aggregation is a slowly seething mass which, however, remains in one area at all times. Individuals that reach the edge of the

4 There was one exception: a large recently formed mass was made up of individuals with large hind-legs, a few with one foreleg, and only an occasional one with all of the limbs present.

mass, invariably turn back into it. Many tadpoles at the top of the mass swim quickly to the surface to gulp air. These immediately swim directly downward and reenter the aggregation. Younger tadpoles may pass such schools within a few inches but pay no attention to them till they themselves reach the proper stage of development.

The area covered by such an aggregation varies from a few square inches to over 2 feet square depending primarily upon the number of individuals in the proper stage that happen to make contact with each other at any time and place. Several aggregations may be formed at the same time in different parts of the pool. Two small aggregations in the process of forming near each other were observed to merge into one when their edges came together.

Such social aggregations may easily be broken up temporarily. When a long pole was lowered slowly into the middle of such a mass the reaction was prompt and violent. Tadpoles scattered in all directions, obviously acting as individuals. Within two minutes after they had resumed their normal rate of swimming small clumps were again forming and within fifteen minutes all had again become aggregated. This experiment was performed several times with different aggregations, always with the same result except that sometimes the re-aggregation was into two or three smaller masses instead of a single large one.

The formation of the aggregations and the final dispersal of individuals did not appear to be correlated with time of day. Neither was there any correlation with depth of water. Some aggregations were formed in a few inches of water, close to the bank, while others were produced in the deepest parts of the pool. The latter were the more frequent because, prior to aggregation, there were more tadpoles in the deeper water.

I failed to get as clear-cut observations on the dispersal of such aggregations as upon their formation. As nearly as I could determine, there is no mass movement toward the bank. Instead, after some hours individual tadpoles begin to leave the edge of a mass to swim directly to some point on the bank, and to crawl out. At this time the tail is still long. On the bank, the final stages of metamorphosis set in and proceed at a very rapid rate. Within three or four hours, the tail entirely disappears, the mouth and head change, and the transformation is completed. At this time individuals measured while alive ranged between 8 and 10 mm. total length, average 8.7 mm., and mode 8 mm., with a mean weight of 0.12 gram.

The significance of the aggregations of these tadpoles is not apparent but their social nature is quite evident. It should be noted that while all of the tadpoles of *S. hurterii* under observation in nature formed such aggregations at a definite developmental stage and that tadpoles of other species present did not do so at any time, all observations were made in a single pool. How much the phenomenon is related to something inherent in these organisms and how much to reaction to the environment, cannot definitely be stated until opportunity is afforded to follow the metamorphosis in different types of pools. This is the more evident from the fact that metamorphosis of larvae of *S. hurterii*, taken both as eggs and as larvae from this same pool, proceeded in laboratory cultures in what appeared to be a normal manner, with no suggestion of an aggregation in three separate lots.

Aggregations of tadpoles of other species appear to be infrequent. I have observed the development of both *S. bombifrons* and *S. hammondii* (the former many times and in many different sorts of pools) without seeing anything suggesting social aggregation. *S. couchii* did not show it in laboratory cultures. On the other hand, on three different occasions *young* tadpoles of *Bufo woodhousii fowleri* have been found aggregated in dense clumps in shallow water when there seemed to be nothing to suggest individual reactions to a food object. One of these was along a sandy beach of the deep and slow flowing Mountain Fork River in McCurtain County, Oklahoma. Another was in a very sandy creek 3 miles S.E. of Atoka, Oklahoma. The only obvious similarities in these three environments were the presence of a sandy bottom and very shallow water (maximum, 2 inches). As the shallowness of the water was not the result of evaporation, one cannot postulate concentration of chemicals as a factor in the aggregations.

Aggregation of tadpoles of *Rana sphenocephala* in rapidly evaporating pools, with accelerated metamorphosis, has been described (Bragg, 1940a). These aggregations seem to be of an entirely different type from those observed in *S. hurterii.* At the time that they were studied, the aggregations were not thought of as social; it seemed as if each tadpole was reacting individually to some stimulus in the environment and that the aggregation was the result of such individual reaction to the same external stimulus.

Ball's (1936) observations of larvae of *S. holbrookii holbrookii* (Harlan) are also of interest. He reports a large aggregation of fast moving tadpoles in a quickly disappearing pool. Since various mutilated individuals were found, and since cannibalism was observed, this was interpreted as a feeding aggregation only. Whether the cannibalism was the cause of the aggregation or the aggregation the cause of the cannibalism is not apparent. See also Taylor (1942) for observations on an unidentified Mexican species and Pope (1931), who describes aggregations of Chinese species of *Microhyla* tadpoles and who quotes Annandale and Smith as having seen something of the same thing. None of the aggregations in tadpoles of other species were of the same type as those described here for *S. hurterii.*

The reactions of *S. hurterii* after they have left the water are also noteworthy. The young animals refuse again to enter the pool no matter how much disturbed. It will be recalled that the pool in question was in a clearing and in full sunlight during the day. During transformation thousands of these metamorphosing young were killed by the sun, even when sitting on moist mud not more than 2 to 6 inches from the water's edge. Maximum daily temperatures at this time ranged above 80° F., one day reaching 88°. Larvae that emerged at night found haven beneath oak-leaves, under pieces of partially dried cow-dung or other objects, especially below the seep near the west end of the pool. It is likely that a few emerging in the daytime might also have survived in this manner, for the few suitable objects at the edge of the pool sheltered some recently metamorphosed individuals whenever they were examined.

No actual burrowing was attempted by these tiny spadefoots, in marked contrast to the prairie form, *Scaphiopus bombifrons* Cope, whose young often back into the mud before the tail is appreciably absorbed. For about two weeks, after the last tadpoles had left the pool, juvenile spadefoots could be

found under appropriate objects at any time during daylight; and, when it was not too hot, hopping about in the moist leaves some yards from the pool. At night, they were usually active, presumably feeding. At the end of two weeks, all quite suddenly disappeared. After this only one was found despite thorough search. This one was about a month out of water and at least three times the size at metamorphosis, which would seem to indicate a rapid growth-rate.

An attempt was made to learn something more of the food and growth rates of the young but with little success. Several hundreds were captured just after metamorphosis and various groups put into artificial environments of different types. They died in a wet environment as fast as in a dry one and lived only a few weeks in a large box of moist sand in which oak-leaves from near their native pool had been liberally scattered. Half grown individuals, collected elsewhere, also died within a few weeks in moist sand in which young *S. bombifrons* and adult bufos had lived for many months. These experiences seem to indicate that the young of *S. hurterii* needs a special type of environment in order to survive. This appears to be the reason for the woodland-limited distribution of the species (Bragg, 1944).

Some twenty of these young spadefoots, taken during metamorphosis, were kept for two weeks in a cigar box of moist sand among oak-leaves; and some of them fed readily, day or night, whenever food was offered. Gnats, bugs, moths, and several kinds of tiny beetles were attacked. As was noted in *S. bombifrons* (Bragg, 1941), some of these animals were more aggressive than others in taking food and these grew to be notably larger than their less active fellows in the short time during which observations were made. The method of catching prey was essentially like that of most other salientians. The spadefoot orients itself facing the insect, crawls forward slowly till within striking distance, and then hops quickly and catches the prey with its tongue.

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Abnormal Viscera and Vascular Connections in *Rana pipiens*

By RICHARD B. MILLER

A SPECIMEN of *Rana pipiens* is here reported in which there are venous and cardiac abnormalities of a rather unusual nature, with some of the viscera of the left side reduced or missing. In his review of abnormalities in the blood vascular system of the Salientia, O'Donoghue (1931) records only two for *Rana pipiens,* although, as he states, it has been estimated that 500,000 specimens are dissected per annum in the United States alone.

The specimen, whose abnormality was discovered during class dissection, was an adult female with the ovaries well filled. Dissection had proceeded as far as the removal of the sternal portion of the pectoral girdle; the veins were intact and the heart still beating. The principal abnormalities are shown in the diagram (Fig. 1).

PRE-CAVAL VEINS.—No trace of a left pre-caval vein was found. The left external jugular, innominate and subclavian veins enter the lateral border of a circular vessel. From the mesial border of this circle a vessel (the transverse anastomosis) runs across the arterial trunks just anterior to the heart and joins the right subclavian vein at the point where it enters the right pre-caval. The subclavian, innominate and external jugular veins of both sides, with their tributaries, are otherwise normally constituted.

The right pre-caval is swollen and much longer than normal. The common vein formed by the joining of the transverse anastomosis and the right subclavian is firmly fused to the right pre-caval just posterior to the junction of the right innominate and external jugular veins. Dissection revealed that they are in open communication at this point. A pulmonary vein enters the right pre-caval vein from the left side and anterior to the heart.

Fourteen cases of abnormal pre-caval veins in *Rana temporaria* have been reviewed by O'Donoghue (1931, 1933, 1935). In all of these the right pre-caval was the missing vein. An abnormality in these veins has been twice reported in *Rana esculenta*. One of these (O'Donoghue, 1933) lacked the right pre-caval; the other, Holle's specimen, had the left missing and constituted the only record of this condition to date. In fourteen of the sixteen recorded cases of this abnormality the transverse anastomosis tends to involve the external jugular veins at their distal ends. Of the other two, one possessed a transverse anastomosis very like the present specimen, but without the loop at the left side; the other (*R. temporaria*, O'Donoghue, 1935) was unusual in possessing two transverse anastomoses, one distal and one proximal in position. The present specimen evidently combines two unusual features, absence of the *left* pre-caval vein, and the presence of a ***proximally*** located transverse anastomosis.

HEART.—A superficial examination of the heart conveys the impression that it is normal except for a great reduction of the right atrium and an enlargement of the left. More careful examination and dissection reveal that only one atrial cavity is present; the left atrium is probably missing. The right atrium has been enlarged and squeezed over to the left side by the development of a dilation of the sinus venosus and pre-caval vein of the right side. Only the right half of the sinus venosus is present. It is possible that the atrium represents the undivided right and left atria, but this seems improbable in view of the fact that the pulmonary vein, which normally enters the left atrium, fails to enter the heart. The sinu-atrial and atrio-ventricular valves and the conus arteriosus are normal in appearance.

THE LUNG AND PULMONARY VEIN.—Only the right lung is present; it is well developed and somewhat larger than normal. No trace of the other lung was discovered. The pulmonary vein leaves the apex of the lung and passes forward and to the left, dorsal to the heart; at the level of the left arterial trunk, slightly proximal to the origin of the arterial arches, it turns sharply to the right, and progressing dorsal to the arteries, crosses in front of the heart to enter the right pre-caval vein. The course of the vein is normal as far as the left side of the heart at which point it should enter the left atrium. With the absence of this structure the abnormal connection with the right pre-caval vein is formed.

The anterior abdominal vein.—This vein is normally constituted posteriorly, but anteriorly enters the right subclavian vein. There is no connection with the hepatic portal system. O'Donoghue finds in his cases and

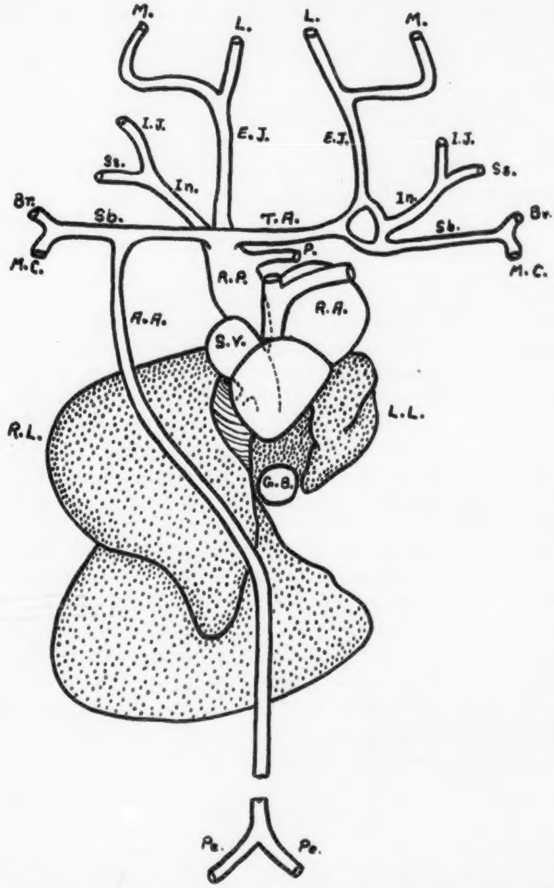

Fig. 1. Diagram of the heart, liver and adjacent veins, ventral view. The posterior caval vein and the right hepatic vein are shown in dotted lines beneath the ventricle. A. A., anterior abdominal; Br., brachial; E. J., external jugular; G. B., gall bladder; I. J., internal jugular; In., innominate; L., lingual; L. L., left lobe of liver; M., mandibular; M. C., musculocutaneous; P., pulmonary; Pe., pelvic; R. A., right atrium; R. L., right lobe of liver; R. P., right pre-caval; Sb., subclavian; Ss., subscapular; S. V., sinus venosus; T. A., transverse anastomosis.

others that a persistent right anterior lateral abdominal possesses a connection with the hepatic portal vein in six out of seven; a persistent left anterior abdominal in ten possesses no hepatic portal connection. He concludes from this and other considerations that it is the right lateral abdominal vein

that acquires a hepatic portal connection during normal development. The present specimen offers an exception to this condition.

LIVER.—In the normal *Rana pipiens* the left lobe of the liver is partially subdivided into two lobes which together are much larger than the single right lobe. In the specimen under consideration the left lobe is reduced to a mere vestige and the right lobe is unusually large and partially subdivided into two lobes. In some way the growth of the left lobe was inhibited; the hypertrophy of the right lobe appears to be compensatory. No hepatic vein is present on the left side. The hepatic portal vein sends two large branches to the right lobe and one small one to the left. An abnormality of the liver in which the right lobe is reduced and the left greatly enlarged is described in *Rana temporaria* by O'Donoghue (1935).

ARTERIES.—The arterial system appears to be perfectly normal except for the absence of the left pulmonary artery. This is to be expected since the left lung is missing.

DISCUSSION.—Of the two abnormalities reported in *Rana pipiens,* one (Watt, 1915) had the ventricle anterior to the atrium and considerably distorted in shape, due to the retention of the dorsal mesocardium. In the other (Young, 1924) the systemic arches failed to unite, and were vestigial beyond the origin of the subclavian arteries of each side. An artery running *forward* between the kidneys gave off a normal coeliaco-mesenteric artery in front; behind it was connected through the left iliac artery with a vessel that ran, dorsal to the spinal nerves, to join the left subclavian artery. The specimen described in the present paper is unusual, in this species, by possessing marked venous abnormalities.

It is difficult to imagine any event during development that could simultaneously affect the subsequent history of heart, lungs and liver. There was no sign of external injury, which would certainly be evident had the condition resulted from an accident. Moreover, the specimen had been kept alive in captivity for some weeks, and had survived many more normal, but less robust, companions. Apparently this was a healthy individual.

I take this opportunity of acknowledging my indebtedness to Dr. Winifred Hughes of the Zoology Department, University of Alberta, who has been helpful in the preparation of this article.

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The Status of *Testudo terrapin* Schoepf

By M. B. Mittleman

Recent acquisition of a copy of Johann David Schoepf's [1] *Naturgeschichte der Schildkröten* for my personal library has prompted some investigation into the nomenclature of turtles and of Schoepf's background. The *Historia Testudinum* is extensively quoted, although it appears that in many instances authors have not consulted it directly but have copied synonymies compiled by other writers. The *Naturgeschichte* is a German rendition of the *Historia,* but is lengthier textually, due to the greater verbosity of German as compared to Latin, and also because of the inclusion of some extra discussions under the respective species headings.

As far as can be determined, both editions were published simultaneously; neither bears any reference to the other, and the publication dates of the individual fascicles and plates in both editions are the same. Both editions were published with the plates colored, or black-and-white. The publication dates of the separate fascicles of each edition are as follows:

Naturgeschichte der Schildkröten
Heft 1 & 2; text A–D; tab. 1–10; 1792.
Heft 3 & 4; text E–L; tab. 11–16, 18–20; 1793.
Heft 5; text M–R; tab. 17, 21–25; 1795.
Heft 6; text S–U; tab. 26–31; 1801.

Historia Testudinum
Fasc. I et II; plag. A–D; tab. I–X; 1792.
Fasc. III et IV; plag. E–K; tab. XI–XVI; XVIII–XX; 1793.
Fasc. V; plag. L–O; tab. XVII, XXI–XXV; 1795.
Fasc. VI; plag. P–R; tab. XXVI–XXXI; 1801.

The *Historia* has a 12 page foreword, followed by 136 pages of text, while the *Naturgeschichte* also has a 12 page foreword (unnumbered) but is followed by 160 pages of text. In both editions there are 34 plates, although they are numbered only up to 31; plates 16, 18, and 30 are double plates. Both texts make mention of plates numbered 32–34, but these were never published, due, no doubt, to the posthumous appearance of the final signatures of both editions. The numbering of the plates is identical in both editions. The difference between the numerical designations of the plates and their actual number has resulted in some errors in bibliographic works (Sherborn, 1902; Wood, 1931). It is to be noted that plate 17 did not appear in its proper sequence, but was published with plates 21–25 in 1795.

Both editions are rarities, the German one more so. Inquiries made to twenty-three of the leading university and private libraries in the United States and Canada reveal eleven copies of the *Historia* (several of them incomplete) located in the libraries of the University of California, Cornell University, Academy of Natural Sciences, Chicago Natural History Museum, American Museum of Natural History, University of Michigan, United States National Museum, Museum of Comparative Zoology, New York Public Library, Lawrence M. Klauber, and the Redpath Library of McGill University. Of the *Naturgeschichte* I was able to locate only eight copies in the following libraries and institutions: University of California, Academy of Natural

[1] Usually spelled Schoepff in herpetological papers which cite the author's name as it appears in his *Historia Testudinum;* I have not used this varietal orthography, but prefer instead the anglicised Schoepf derived from the German Schöpf.

Sciences (heft 1 only), Chicago Natural History Museum, United States National Museum, New York Public Library, Lawrence M. Klauber, Redpath Library of McGill University, and my personal copy.[2]

Schoepf was born March 8, 1752, at Wunreidel in the principality of Bayreuth, the son of a wealthy merchant. He attended the Gymnasium at Hof, and entered the University of Erlangen in 1770. His principal field of endeavor was the study of medicine, but he also attended lectures in the natural sciences. In 1773 he went to Berlin for work in forestry, and followed this by studies and travels in Saxony, Bohemia, Vienna, Carniola, northern Italy and Switzerland. He returned to Erlangen, obtained his degree of Doctor of Medicine in 1776, and was appointed chief surgeon to the Ansbach troops (Hessian mercenaries) destined for duty in America. He landed in New York City on June 4, 1777, and from that date until July 22, 1783, he served throughout the campaigns of the American Revolution at various British Camps. From July, 1783, through most of 1784, he travelled through the states of New Jersey, Pennsylvania, Maryland, the Carolinas, east Florida, and finally, the Bahamas. His experiences and observations in the course of these wanderings compare favorably with those of Kalm and Bartram, and are fascinatingly related in his rarely-seen *Reise . . . einige der mittlern und südlichen . . . Nordamerikanischen Staaten nach Ost-Florida und den Bahama-Inseln* . . . (1788), or in Morrison's translation (1911). On his return to Europe in the latter months of 1784, he renewed his association with the University of Erlangen, and while teaching medicine, produced in addition to the *Reise* and two editions of his turtle monograph, a monograph on the mineralogy of eastern North America, a materia medica, a study of the effects of opium in venereal diseases, notes on his experiences and conditions in North America, a note on the common perch of North America, and a study of the fishes inhabiting the waters of New York. Other papers published before his return to Erlangen include a study of climate and diseases in North America, and a note on American frogs. At the time of his death, on September 10, 1800, he was president of the United Medical Colleges of Ansbach and Bayreuth.[3]

Schoepf's scope of interest was equalled only by his meticulous attention to details and his extraordinary scientific abilities. While the importance of the *Allgemeine Naturgeschichte der Schildkröten* of Schoepf's friend and contemporary, Johann Gottlieb Schneider, should not be disparaged, it cannot compare in breadth and finish with Schoepf's publications on the Testudinata. Schoepf's writings reveal a discernment and scepticism not usually associated with this period in the infancy of systematics. As Shaw has pointed out (1802: 8), Schoepf was apparently the first writer to question the Linnaean arrangement of turtles according to the number of claws or toes, and

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2 After these notes had gone to press, I learned through the kindness of Mrs. Helen T. Gaige that the *Historia* is somewhat commoner than I had thought, and in addition to the copy in the University of Michigan General Library listed above, several others are in the Museum of Zoology. The *Naturgeschichte* still seems to be a rarity, although Mrs. Gaige advises me of two more copies at Ann Arbor.

3 Much of the foregoing has been taken from Dr. Alfred J. Morrison's excellent review "Doctor Johann David Schoepf" (German-American Annals, n.s., 8 (5-6), Sept.-Dec. 1910: 255-264). Dr. Morrison lists among Schoepf's other publications one entitled "Vom Amerikanischen Frosche" which supposedly appeared in *Naturforscher*, number 18, 1782. The only reference to Schoepf, or American frogs, which appears in the "Naturforscher" is in Schreber's description (pp. 185-186) of *Rana pipiens*, wherein is mentioned the fact that Doctor Schoepf collected the specimens at hand (see Kauffeld, Herpetologica, 1, 1, 1936: 11).

while he in some instances utilized equally variable characters, he seems to have been one of the earliest herpetologists to recognize the value of series of specimens.

Amongst the new species figured and described in Schoepf's turtle opus is his *Testudo terrapin* (Historia: 64, pl. 15; Naturgeschichte: 71, pl. 15). There is no question but that this description and plate are at once accurate and clear, and save for his choice of the specific name no problem is involved. His data and illustration are based on specimens collected by himself and Muhlenberg, from the vicinity of Philadelphia and the coastal waters of Long Island, and clearly characterize for the first time the animal currently known as *Malaclemmys centrata concentrica* (Shaw). The action of some authors in relegating Schoepf's *terrapin* to synonymy appears to be unjustified.

To clarify the status of Schoepf's name *terrapin,* the status of the *Testudo terrapen* of Lacépède, 1788, must be inspected. Barbour and Carr (1940: 394) have pointed out that this name is referable to the Jamaican species of *Pseudemys,* and that this animal is hence *P. terrapen* (Lacépède). The name was based on Patrick Browne's brief description of the "terrapin" of Jamaica (1756: 466). Using the same source Browne, Gmelin in the next year described his *Testudo palustris,* and as such, his name stands as a pure synonym of *Testudo terrapen* (Lacépède).

Despite the fact that Schoepf's species was North American, rather than West Indian, and was eventually shown to be generically distinct from the Jamaican species, much uncertainty surrounded the application of his name *terrapin.* Thus, some authors have used Schoepf's name for the American species and Gmelins' *palustris* for the Jamaican one, while others have used names proposed by Shaw, or even applied Gmelin's *palustris* to the American diamondback terrapin (see Barbour and Carr, *loc. cit.*). Baur (1893), in addition to misspelling Schoepf's species, and wrongly crediting *Testudo terrapen* to Bonnaterre instead of Lacépède, erred in believing *T. terrapin* Schoepf to be unavailable for a species of *Malaclemmys.* W. P. Hay (1904: 5) seems to have followed Baur's reasoning, although he does not say so specifically, and similarly confounded the status of Schoepf's species.

To some extent, Schoepf is to blame for this confusion surrounding his proposed name. Immediately below the name *Testudo terrapin* he gives the following references:

> An:– The terrapin, Testudo quarta minima lacustris, unguibus palmarum quinis, plantarum quaternis, testa depressa, ovali. *Brown.* Hist. nat. of Jamaica, pag. 466, n. 4. Testudo palustris. *Linn.* Syst. nat. ed. *Gmel.* n. 23. p. 1041. Terrapen, testa superiora planiuscula et ovata. *Cepede* pag. 228, et *Bonaterre* [sic] n. 26.

A casual glance would make it appear that the author considered his species to be identical with those mentioned in these citations. Very definitely however, Schoepf had no such intention. First, the "An" which begins the citation refers merely to queried affinity, but not identity. Schoepf probably listed the references to Gmelin, Bonnaterre, Cepede, and Browne, to signify his appreciation of the close relationship of their species. Secondly, and more to the point, is the fact that Schoepf's description and figure adequately define his species, and his type locality is clear: "The home is in North America . . . they are bought in the markets of Philadelphia . . . they swim

in the coastal waters of Long Island." If anything further is necessary to show Schoepf's awareness of the distinction of his species and those of Browne, *et al*, it is his statement that Browne's species is restricted to the waters of Jamaica, as contrasted to the North American coastal habitat of his (Schoepf's) form.

The application of Schoepf's *terrapin* to the North American *Malaclemmys* depends on the supposed homonymy. A homonym is defined as "one and the same name for two or more different things." Article 35 of the International Rules states "A specific name is to be rejected as a homonym when it has been previously used for some other species or subspecies of the same genus." Considering these two requirements, Schoepf's name differs from that of Lacépède in the spelling of the final syllable, and if this difference is granted, the problem is largely closed. According to the rules of spelling given in Articles 35 and 36, *terrapin* Schoepf is not a homonym of *terrapen* Lacépède. It seems clear that the application of Schoepf's *terrapin* to the diamondback of the North Atlantic coastal states is justifiable. Shaw's description and plate of *Testudo concentrica* were obviously lifted *in toto*, so that this name becomes a clear synomym. The synonymy of this species then stands as follows:

Malaclemmys terrapin terrapin (Schoepf)

1793 *Testudo terrapin* Schoepf, Naturg. Schild.: 71 (Hist. Test.: 64), pl. 15, type locality; markets of Philadelphia and the coastal waters of Long Island.

1802 *Testudo concentrica* Shaw, Gen. Zool., 3: 43, pl. 9, type locality: Philadelphia markets.

1814 *Emys centrata* Schweigger, Prodromus: 32 (part.); Harlan, Med. Phys. Res., 1835: 153 (part.).

1830 *Testudo palustris* Le Conte, Ann. Lyc. N. Y., 3: 113 (part., *non* Gmelin).

1831 *Emys concentrica* Gray, Syn. Rept.: 27 (part.).

1838 *Emys terrapin* Holbrook, N. Amer. Herp., 2: 13 (part.); *idem*, ed. 2, 1, 1842: 87; De Kay, N. Y. Fauna, 1842: 11.

1842 *Emys palustris* De Kay, N. Y. Fauna: 10 (part.).

1844 *Emys macrocephala* Gray, Cat. Tort. Brit. Mus.: 26.

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1862 *Clemmys terrapin* Strauch, Chel. Stud.: 132 (part.).

1889 *Malacoclemmys terrapen* Boulenger, Cat. Chel. Brit. Mus.: 89 (part.).

1896 *Malaclemys terrapin* Bangs, Proc. Boston Soc. Nat. Hist., 27: 159.

1904 *Malaclemmys centrata concentrica* W. P. Hay, Bull. U. S. Bur. Fish., 24: 16; Stejneger and Barbour, Check List. N. Amer. Amph. and Rept., 1917: 116.

The southern race, *centrata* Latreille, 1801, thus becomes *Malaclemmys terrapin centrata* (Latreille).

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Herpetological Notes

NOTES ON THE YOUNG OF THE BROWN WATER SNAKE.—During the summers of 1940, 1941, and 1942, while engaged on studies of the embryos and young of the brown water snake, *Natrix taxispilota* Holbrook, I made observations and measurements, and recorded the sex ratios of three broods of young born in the laboratory. The pregnant females were obtained from Florida and housed in suitable pens out of doors and in the laboratory. Measurements reported were made within 24 hours after birth.

The breeding season of the brown water snake is usually during the latter part of May and young are born during the first part of August. Both breeding season and parturition period vary, and young may be born as early as June 15 or not until the latter part of September. This is indicative of one of three things: an early or late mating, fall mating, or persistence of viable sperm from a previous mating.

The young are born out of water and usually molt within 18 to 48 hours after birth. In a few of the young snakes molting did not occur for several days. The young were inactive until after molting, when they became very active and capable of drawing blood when they bit. In pattern and scutellation the little snakes agree closely with their parents. Their pattern is strongly marked, the dorsal spots being especially prominent.

The average number of young for the brown water snake, in thirty broods, was found to be between thirty and forty.

On September 13, 1941, a female 1,245 mm. in length gave birth to 34 young, five of which were still-born. One of the living young had a deformed spine, and the tail was twisted and kinked. This specimen died 3 days later. The 21 females ranged in length from 178 to 246 mm., average 238.5 mm. In 13 males the range is 238 to 259 mm., average 251.8. On August 5, 1942, a female 1,285 mm. in length gave birth to 37 young, of which two were still-born. There were 21 females, ranging from 236 to 252 mm., average 242.5 mm. The 16 males measured 246-258 mm., average 251.7. On August 5, 1942, a third female gave birth to 40 young, of which 22 were females and 18 males. The female specimens measured 190-251 mm., average 241.1 mm., and the males 200-268, average 250.6. The sex ratio altogether in the three broods is ♂♂ 47 : ♀♀ 64. The juvenile males average larger than the females, while the reverse is the case in adults.—MALCOLM A. FRANKLIN, *Department of Anatomy, School of Medicine, University of Mississippi, University, Mississippi.*

A SIMPLE AND EFFECTIVE LIZARD SNARE.—The skinks of New Guinea are abundant, but good shelter for them is everywhere and the lizards are wild and wary. It is not difficult to approach within a few feet of them, but it is almost impossible to catch them, except for the rare, misguided individual who feels safe under a fallen breadfruit leaf.

No dust shot equipment was available, so various devices were tried in the endeavor to collect worthwhile series. A sling-shot loaded with coral gravel was totally unsuccessful. A hand pulled snare was too slow. Finally a snap-snare was constructed that is so satisfactory that the writer feels impelled to present a description of it for the consideration of other collectors. No doubt similar snares have been evolved previously, but apparently they are not well known.

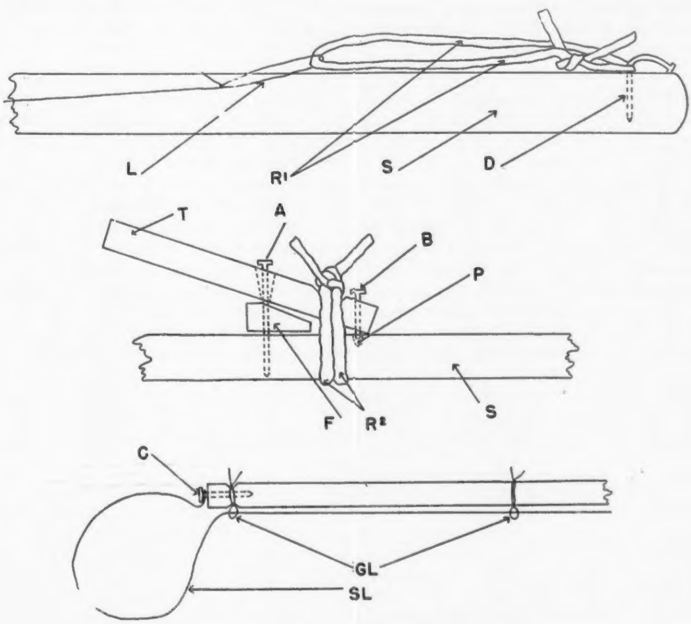

Fig. 1. A simple snap-snare lizard trap.

Construction.—The shaft (S) of the snare is a slender rod 3 to 5 feet long. Either a rough twig or light piece of cane is adequate. A thread (SL) or light cord is attached to a brad (C) at the tip of the rod, passes through a thread guide loop (GL) near the tip of the shaft, and runs along the shaft through a series of small supporting loops. Near the base of the stick the cord ends in a loop (L) around a rubber band (R1). This band is a one eighth inch strip cut from inner tubing and tied with a square knot to make a loop that is about 4 inches long when relaxed. By changing the knot, the tension on the cord can easily be altered. The cord should be just long enough to keep the elastic straightened out when not stretched. The proximal end of the rubber may be secured by a bent nail (D).

About 8 inches from the basal nail (D) is the trigger. The trigger stick (T) is held over the fulcrum (F) by the nail (A). The trigger fits the nail (A) loosely, the nail hole being widest dorsally to permit the motion of the trigger. Toward the end of the trigger stick is a shortened blunted nail (B). The end of this nail protrudes about one

sixteenth inch from the trigger and fits into a shallow pit (P) in the shaft. A rubber band (R2) holds the trigger to the shaft. The trigger is notched to hold the band in place.

To operate, the elastic (R1) attached to the snare line is stretched and caught under the end of the trigger nail (B). The cord is then drawn out into a loop at the tip of the rod. This loop will be roughly 1 x 1½ inches, but can be made larger if the length of the rubber band is also increased. The length and angle of the nail (B) can be varied to produce the desired certainty of grip and ease of release.

This trigger mechanism suffices well enough, but a quicker acting, more delicate one would be a useful improvement.

Disadvantages.—The only real disadvantage of the snap-snare is that in about half of the specimens a narrow ring of displaced scales on the neck is evident, although it it is seldom objectionably conspicuous. Occasional specimens an inch or two long are killed by the noose.

Advantages.—Perhaps a third of the specimens seen are too wild to be stalked or are wise enough to recognize in the noose the extension of the enemy. Of the remainder, we catch about two-thirds of the skinks for which we try. Occasionally a hungry lizard will come running several inches and stand up on his hind legs to inspect the noose, and may even snap at the end of the stick, apparently thinking it the body of an insect of which the string represents the appendages. Most of the lizards regard the approaching noose calmly or with only casual caution. Not infrequently they become more tolerant of the waving noose as one makes repeated efforts to get it around their necks. The slight "snick" of the snare when it is sprung near them in vain seldom frightens the lizards. The construction of the snare is simple. It can be built and operated indefinitely at no cost. It is durable, and easy to repair or adjust.

The snare can be run into brush piles, vegetation or rock crevices and the hiding lizard captured. Without adjustment, it will catch lizards varying in size from those of a body length of several inches down to the newly hatched. If made on a heavier scale it could be utilized for larger forms. The snap-snare might well be used in conjunction with a .22 dust-shot pistol or rifle. The gun could be reserved for wilder specimens and for any very large lizards. The snare does far less damage to lizards than is common with dust shot.—William H. Stickel, *38th Malaria Survey Unit, U.S. Army.*

NEW RECORDS OF REPTILES FROM PORTAGE COUNTY, OHIO.—In "The Reptiles of Ohio," Conant (1938, Amer. Midl. Nat., 20: 1–200) has listed and mapped all known records of reptiles for the state. Records of three species not included for Portage County in Conant's paper have come to my attention. One of my students, Mr. Maurice M. McClay, engaged in an ecological survey of the snakes of Atwater Township, Portage County, collected the three species not previously recorded, and two of them were later collected by my zoology classes at localities near Kent, also in Portage County.

Eumeces fasciatus (Linnaeus).—A single specimen of the blue-tailed skink was found in the summer of 1937. The nearest recorded locality is at Burton, Geauga County, some 30 miles directly north. With my class, I collected another specimen in a Larix-Vaccinium-Chamaedaphne bog on June 25, 1940, south of Kent.

Sistrurus catenatus catenatus (Rafinesque).—The swamp rattler was collected by Mr. McClay. One specimen was taken from a tamarack bog in 1935 and two from an oat field in 1939. The nearest recorded locality is at Hartville, Stark County, about 12 miles to the south.

Opheodrys vernalis (Harlan).—The smooth green snake was collected in the summers of 1935 and 1937 by Mr. McClay. A group of students found a specimen of this species along the banks of the Cuyahoga River in Kent, in September, 1940. I collected another at Kent in April, 1941. In the spring of 1943, a third was collected at Kent by Miss Vivian Gage, who brought it to our laboratory. Conant states that the species is comparatively rare in Ohio (16 records published), but quotes a report of it as common at Ira, Summit County. Kent is about 12 miles in a direct line east from Ira, and about the same distance south from the one known record of Geauga County at Geauga Lake.—Ralph W. Dexter, *Kent State University, Kent, Ohio.*

MATING OF THE GRAY RAT SNAKE IN ALABAMA.—On June 10, 1943, during troop movements on the Camp Sibert Military Reservation near Gadsden, Alabama, the writer noticed two gray rat snakes, *Elaphe obsoleta confinis* Baird and Girard, in a copulating position. Both were good sized individuals of approximately 4 feet. They lay motionless in short grass, stretched to full length in the full glare of the afternoon sun. The snakes were pressed closely together and the posterior half of what was presumably the male was twice entwined about the female. The male's snout was pressed into the side of the neck of the female. The presence of many close observers evidently disturbed the pair for they quickly separated and took refuge in a nearby den beneath the roots of a large pine tree. No effort was made to stop them and it is not known whether actual genital contact had occurred.

On June 14 the writer revisited the den, which was apparently an old mammal burrow, and excavated it. Two large males were collected for the Cornell University Museum. The den was quite extensive; four other snakes of the same species were found, the last at 2 feet below ground level.

The gray rat snake is rather common on the reservation; several were observed throughout June and a total of seven found DOR.—RICHARD C. SNYDER, 2ND LT., CWS, *94th Chemical Bn., Camp Rucker, Alabama.*

FALL AGGREGATION OF THE QUEEN SNAKE.—A series of thirty-two *Natrix septemvittata* Say, found closely associated on October 27, 1940, were collected by Messrs. J. H. Martin and H. J. Walter, of Dayton, Ohio, and presented to the museum for examination. None of the specimens were young-of-the-year, and the group was evidently not simply a collection of young from an off-season birth. The average length of twelve specimens was 58.4 cm., or about 23 inches.

These snakes were found in Montgomery County, Ohio, about 5 miles up the Miami River from the center of Dayton, on a mud river bank which had been undercut by the current. The river surface of the bank was devoid of vegetation, but had a number of exposed roots of trees hanging out; and several mammal burrows opening toward the river. Situated along the top of the bank, about 8 feet above the river surface, were a number of leafless saplings with denuded roots, overhanging the stream. The collectors' attention was drawn to three small saplings from which they saw objects dropping into the water. When they had determined that the trees were full of snakes, many basking in the late afternoon sun about 10 to 15 feet above the water, they hurried forward to capture as many as they could.

Mr. Martin waded into the river below the trees, and Mr. Walter climbed out into the saplings, grabbing as many snakes as he could, and shaking others down to his companion. Perhaps ten or fifteen snakes fell into the river and escaped capture. Although a few of the specimens seemed lethargic, the majority were fully active.

These snakes were collected at a time when individuals of *septemvittata* were becoming quite scarce along the river. A week earlier some cold weather was experienced in this locality. It seems that these snakes had either already gathered for hibernation, and had ventured out because of the warm weather, or were gathering for hibernation.—JOHN THORNTON WOOD, *Public Library Museum, Dayton, Ohio.*

AN ALBINO FALSE MAP TURTLE.—A false map turtle (*Graptemys pseudogeographica pseudogeographica* Gray) has been received from a dealer at White Castle, Louisiana, who reports that it is the fourth albino specimen that he has seen in many thousands of turtles handled since 1927. The ground color in life is pale yellow-white with the dorsal "map" pattern composed of orange lines; the faded slate-gray pattern on the plastron and under the marginal scutes of the carapace is the only trace of darker color. The usual lines are visible on the head and appendages but they are all too light to be described as slate colored. The pupil of the eye is very distinct but reddish, surrounded by yellow-white. The length of the carapace is 40 mm. General development of the body appears to be perfectly normal.—CHARLES E. BURT, *Southwestern College, Winfield, Kansas.*

HOW *NATRIX TAXISPILOTA* EATS THE CHANNEL CATFISH.—Some ichthyologists have questioned the ability of water snakes to swallow living catfishes, because of the spine-locking mechanism of these fish. The following observation, made on the Chickahominy River in New Kent County, Virginia, not only proves that snakes can accomplish this feat, but also indicates the manner in which it is performed.

On September 10, 1942, at 9:00 A.M., a *Natrix taxispilota,* approximately 4 feet in length, was observed swimming shoreward with a catfish (*Ictalurus*), about 10 inches long, held partly out of the water. The fish was gripped about midway on the left side and was flopping vigorously. When the snake reached shallow water it slowly began to shift its grip toward the fish's head. As the snake's jaws moved forward, the pectoral fin on the left side of the fish was extended and the spine set. At this point the snake's jaws reached the pectoral spine, shifted dorsally until the lower jaw could pass above the spine, then back down again, and over the corner of the fish's mouth. With a few more movements the fish was lined up straight and swallowing started. There was no further interruption until the pectoral fins were reached. These fins, which had been relaxed, were now extended, and the spines set in position. The snake's jaws reached the base of the fins, then slid up the spines a short distance. At this point the snake paused and waited until the fish began to flop. When the pectoral fins were released, as part of the fish's struggling movements, the snake's jaws closed down on the spines, preventing them from being raised again. The next obstacle was the raised dorsal spine. Once more the snake got its jaw up over the base of the spine, but this time it turned the fish over, with the apparent intention of pushing the spine against the shore. While the lower jaw was uppermost, and out of the water, the snake paused for a breathing spell. In this position it had the head of the fish completely engulfed, and gills held shut. The fish started to struggle again, and in so doing released the dorsal spine, which was then held down by the pressure of the snake's jaw. Up to this point the swallowing had been accomplished by forcing the jaws gradually forward, one side at a time. After the widest part of the fish's head had been passed, however, the snake literally crawled outside of the fish. The jaws gripped the fish tightly and its body was drawn up over the fish in a series of folds, then the jaws relaxed and the head and anterior portion of the snake slid forward, engulfing about half an inch of fish at a time. This was repeated until all but the tail had disappeared. Then the snake seemed to notice its audience of three for the first time, and swam away, swallowing the tail as it went. The whole process, from the time the snake was first sighted 20 feet from shore until the fish was swallowed, took about 15 minutes.

In this area *Natrix taxispilota* and *N. sipedon* are often seen feeding on the various species of catfishes that are abundant here. In the river, near the dock where most of my observations have been made, *taxispilota* is the most common water snake, and the channel cat the most common catfish. One *taxispilota* was observed swimming toward shore with a sun fish (*Lepomis sp.*), but before it reached the shore the fish escaped. All of the water snakes observed feeding on fish have brought their prey to shore before swallowing it; some of them have taken the fish out of the water, while others have stopped at the water line. Although various other fishes, such as minnows, sun fishes, etc., are common in the water near shore, catfishes seem to be caught more frequently by water snakes. It is interesting to note that all of the water snakes observed in the act of feeding have had a live catfish, although dead specimens are not uncommon along the shore.—NEIL D. RICHMOND, *Shackelford Farms, Lanexa, Virginia.*

CANNIBALISM IN THE COMMON CORAL SNAKE.—Recently at Sebastian, Indian River County, Florida, Mr. George Nelson of the Museum of Comparative Zoölogy caught a 28¾-inch (620 + 45⁺ mm.) male coral snake (*Micrurus fulvius fulvius*) and put it in a vivarium. Shortly afterwards he returned to fetch it and found that the snake had disgorged another male coral of 23¾ inches (535 + 77 mm.), thus only 5 inches shorter than itself. The disgorged snake, though dead, was in such perfect condition that it must have been swallowed very recently. Mr. Nelson also brought back a fine 33½-inch (780 + 70 mm.) female from the same locality.—ARTHUR LOVERIDGE, *Museum of Comparative Zoölogy, Cambridge, Massachusetts.*

ADDITIONS TO THE LIST OF AMPHIBIANS AND REPTILES OF GREAT SMOKY MOUNTAINS NATIONAL PARK.—Since the publication of the writer's paper in 1939 (King, 1939, Amer. Midl. Nat., 21: 531–582) four additional species have been found in or immediately adjacent to the Park. These include two additional salamanders, one of which is new to Tennessee, a frog, and a turtle.

Leurognathus marmorata intermedia (Pope).—Specimens of this salamander were found in collections made by Dr. Carl Hubbs and the writer in the Great Smokies on September 2, 1937, and again on June 27, 1940. The 1937 collections came from Abrams Creek and two tributaries in Cades Cove, Blount County. The species was noted by Dr. Joseph R. Bailey, who examined the material at the University of Michigan Museum of Zoology.

The Abrams Creek specimens, the first Tennessee record for the subspecies, were taken between the elevations of 1700 and 1800 feet. This is much lower than Pope reports (Pope, 1928, Amer. Mus. Nov., 306: 14) for collections from Davis Gap near Waynesville, North Carolina (approximately 3500 feet). Both adults and larvae were found. The specimens were confused in the field with adult males of *Desmognathus fuscus fuscus*.

The species was encountered the second time on Kephart Prong of the Occonalufty River, at an elevation of about 2800 feet, about 3 miles above Smokemont, Swain County, North Carolina. Several specimens were taken by Dr. Hubbs and the writer while seining for fish near the U. S. Fish Hatchery. They were found on the bottoms of the pools or hiding under accumulations of leaves and submerged litter.

Hemidactylium scutatum (Schlegel).—The first specimen of the four-toed salamander to be found in the Great Smokies was taken by Arthur Stupka, Park Naturalist, in Cades Cove, on March 17, 1940. Visiting the same locality on April 4, 1940, I found several additional specimens under the moss on fallen tree trunks and logs in a small gum swamp. The ground was damp with a cover either of heavy leaf litter or sphagnum moss. Normally several inches of water cover the ground during the spring months. Three females were found guarding nests of eggs, so located that upon hatching the larvae would readily drop into the water. Dr. A. J. Sharp, of the University of Tennessee, found a specimen of the four-toed salamander in a sphagnum bog on the head of Meadow Branch, a tributary of the West Prong of Little River in the Great Smoky Mountains National Park, at an elevation of about 1800 feet, in August, 1941.

Habitats suitable for this salamander are very limited in the Great Smokies, so it is probable that the species will be found only in a relatively few places. Both of the above localities are in Blount County, Tennessee.

Acris crepitans (Baird).—This cricket frog occurs in the vicinity of Chilhowee, Tennessee, along the western boundary of the Park. It is common in back-water pools and in small ponds located in pastures along highway U.S. 129. I found the frogs for the first time on June 14, 1940.

Pseudemys troostii (Holbrook).—This turtle is common along the Little Tennessee River, which flows close to the western boundary of Great Smoky Mountains National Park. It has been seen on several occasions along the lower portion of Abrams Creek (below 1,000 feet elevation). It has been observed at Tapoco Lake (an impoundment of the Little Tennessee River), which lies at approximately 1,300 feet elevation. The occurrence of the form in these waters warrants its inclusion in a list of the Park fauna.

Gyrinophilus dunni Mittleman and Jopson.—In my report of 1939, I listed *Gyrinophilus danielsi* x *duryi* as occurring in the Great Smokies at elevations below 2500 feet. Since that report appeared, Mittleman and Jopson have described *Gyrinophilus dunni*, evidently based on specimens like those that I had referred to as *G. danielsi* x *duryi*.

Lampropeltis getulus getulus (Linnaeus)—*L. g. nigra* (Yarrow).—In 1939, I misquoted Trapido in stating that this author places the zone of intergradation between *L. g. getulus* and *L. g. nigra* in the bottom lands of the Mississippi. The species referred to by Trapido (1938, COPEIA: 49) was *L. g. holbrooki*, not *L. g. getulus*. My account of the distribution of the king snakes within the Park still holds, and is in accord with that outlined by Schmidt and Davis (1941) for the southeastern United States.—WILLIS KING, *Division of Game and Inland Fisheries, Raleigh, North Carolina.*

COURTSHIP OF *PLETHODON METCALFI*.—While collecting amphibians and reptiles in the southeastern states for the Carnegie Museum during the summer of 1939, we had an opportunity to witness part of the courtship of *Plethodon metcalfi* Brimley. The observation was made a little after 9 P.M., near the Yonahlossee Road, 1½ miles east of Linville, N. C. There had been some rain during the afternoon and the night was partly cloudy, with a heavy dew. The air temperature was 65° F. On a gentle slope, where logging activities had removed underbrush and most of the leaf mold, exposing bare soil, we saw a number of *P. metcalfi*. Two of these were apparently engaged in courtship behavior. The male was walking very slowly and at the same time undulating his tail, with the base of the tail arched sufficiently so that the cloaca was not in contact with the ground. The female was following the male with her chin on the base of his tail, which extended back and beneath her. We watched this pair for twenty-five minutes during which time they kept moving slowly in a roughly circular path about 10 feet in diameter; the male pausing occasionally as though choosing a path. The light of our head lamps seemed to have no effect upon their activity, although we approached within 2 feet of them. When collected, the cloaca of the male was distended and partially everted, although no spermatophores could be found. In the light of our lamps the male appeared darker than the female.

According to Noble and Brady (COPEIA, 1930: 52) the general pattern of courtship is essentially the same in the species of plethodontid salamanders in which it has been observed. The activity noted by us corresponds to the general pattern reported by these authors. The preliminary movements, which, in other species, consist of the male rubbing his lips, cheeks, and mental gland or side of the body to the snout of the female were not observed, nor was the male seen to turn and push the female in the cloacal region with his nose although the pair continued to move in a circular path.—N. BAYARD GREEN, *Marshall College, Huntington, West Virginia,* and NEIL D. RICHMOND, *Lanexa, Virginia.*

DEVELOPMENT OF *BUFO MARINUS* LARVAE IN DILUTE SEA WATER.—Recent reports in the literature have shown that several amphibians may develop successfully in brackish water. *Bufo marinus* Linnaeus, the tropical American toad, has been traditionally associated with the sea since the time of Linnaeus, who may be thought to have implied by the name that it might frequent bodies of salt water.

In the fall of 1941, three series of experiments were carried out on the larvae of this species at Honolulu to determine their viability in various dilutions of sea water.

In the first series, fertilized eggs were placed in 50, 25, 10 and 5% sea water and in tap water. Those in 50% sea water died in the late stages of cleavage; those in 25% hatched but died shortly thereafter. The others continued to live and develop for nearly 30 days. Because of the large number of abnormal individuals that appeared, possibly due to overcrowding, the experiment was terminated.

A second series of eggs was placed in 25, 20, and 15% sea water and tap water. The animals in 25% sea water died in cleavage without hatching; a few of those in 20% hatched and reached 2-3 mm. in length, but all had died at the end of 3 days. The others appeared to be developing normally at the end of 8 days when the experiment ended.

The third series of eggs was at the yolk plug stage when placed in 15 and 10% sea water and in tap water. Mortality appeared to be slightly less in the dilute sea water, and development in the early stages, at least, somewhat accelerated.

Twenty-seven days after laying, the first completely metamorphosed animal was taken from the 15% sea water and 2 days later metamorphosis was occurring in the other solutions. Thereafter, over a period of 9 days, metamorphosed animals were taken from all solutions.

In general, these preliminary experiments seem to show that low concentrations of sea water constitute a favorable environment for the development of *Bufo marinus* larvae.—CHARLES A. ELY, *Department of Zoology, University of Wisconsin, Madison, Wisconsin.*

FOOD OF SALAMANDERS IN THE NORTHWESTERN UNITED STATES.—During the course of a collecting trip during the summer of 1935 in northwestern California and southwestern Oregon, food studies were made for four species of salamanders.

Batrachoseps attenuatus attenuatus (Eschscholtz) was found in rotting logs of *Sequoia sempervirens* and *Tsuga heterophylla* in Del Norte County, California. In a dead *Sequoia* log in one small space about 4 feet square, between the bark and the moist decaying wood, about twenty-five *Batrachoseps* were found. When alarmed, they curled and uncurled with jerking movements of the body, and many were lost when they eluded capture by snapping out of one's hand and falling in the dense undergrowth. The stomachs contained legs of spiders, lepidopteran scales, and mites.

Larval forms of *Dicamptodon ensatus* (Eschscholtz) were found in the clear streams flowing through the mossy floor of the redwood forest in Del Norte County, California. Of five larvae examined, four contained *Hyalella knickerbockeri,* with as many as 27 of these amphipods in the stomach of one individual. A sowbug had been ingested by one, while another had eaten 10 caddice-flies of the *Setodes* type. One ascarid was found in each of two stomachs, of five examined.

A number of *Triturus granulosus mazamae* Myers were taken from the type locality, Crater Lake in Crater Lake National Park, Oregon. Adults found in the water and along some algae-covered rocks were examined. A plankton tow taken at the same time showed practically no food available in the water. Some insects are blown onto the surface of the water by a down-draft from the rim of the crater surrounding the lake. A saw-fly and a beetle had been swallowed, and aquatic food animals included *Hyalella,* an occasional snail, *Notonecta,* and the larvae of tipulids and stone-flies.

Ambystoma macrodactylum Baird was quite abundant at Crater Lake. The adults were found under rocks near the water, while the larvae were found under rocks overlying water connected with the lake. Ten adults were examined, and all of the stomachs contained remains of insects and spiders exclusively, including larvae of stone flies, crane-flies, and dragon-flies, and adults of beetles, crane-flies, mosquitoes, house flies, and camel crickets. Five larvae of *Ambystoma macrodactylum* were examined in which the food consisted mainly of larvae and adults of *Chironomus,* with a few *Hyalella, Cyclops,* and odonate larvae.—CLINTON F. SCHONBERGER, *University of California at Los Angeles, California.*

BLACK SNAKE ATTACKS A BOY.—It is generally believed that a black snake will not attack a person, although Schmidt and Davis in their *Field Book of Snakes of the United States and Canada* (p. 126) say "—during the breeding season an occasional individual may advance toward an intruder." Further on these authors report, "Mating has been observed on May 12 —." The following observation records an instance of belligerent behavior of a black snake.

On May 7, 1944, Leon Gonthier, my 13-year old neighbor whose herpetological interests are indicated by the half dozen snake cages in his backyard containing an equal number of different species, recounted an experience of his earlier in the day. At about 3:00 P.M. he located a black snake, apparently *Coluber constrictor constrictor* Linnaeus, crossing an open space in an abandoned weed field at Newington, Connecticut. "When I ran towards the snake about 20 feet away, it turned and came for me. As I bent over to catch it, the snake grabbed me by the shirt and hung on. I caught it by the neck, and could see that its scales were dull and not keeled. It was so ugly I put it on the ground and held it off with a stick. It jumped twice more at me and came clear off the ground." In the words of a sincere conservationist, he added, "I wish now I had brought it home, but my other black snakes did not live long in captivity, so I left it." There seems to be no good reason for doubting the young man's account of his experience.—GORDON T. WOODS, *State Board of Fisheries and Game, Hartford, Connecticut.*

Ichthyological Notes

NOTE ON BREEDING GROUNDS OF BLUE MARLIN AND SWORDFISH OFF CUBA.—Up to the present, there has been no record of larvae, eggs, or ripe females of either blue marlin, *Makaira nigricans ampla* (Poey), or white marlin, *Makaira albida* (Poey), and although anglers have reported ripe females, these data have been confused by uncertainty in the identification of the species.

We now have material that indicates a breeding ground of the blue marlin off the northern coast of Cuba. Gonads of this fish were brought to us through the courtesy of Winston Guest, Van Campen Heilner, and Ernest Hemingway, from specimens taken on July 30, 1942, off Calasi, on the north coast of Cuba. They were caught in the Gulf Stream about 1½ miles offshore. The fishes weighed 247, 150 and 125 pounds "dressed" (eviscerated, all fins and head removed). The gonads averaged 2 feet long and about 2½ inches greatest diameter. Histological slides of the eggs, which measure 0.9 mm. show them in breeding condition and within a very short time of deposit.

Fishermen claim that these fish off Cuba are filled with eggs from July through October, and that the white marlin is in spawning condition from January to March. Unfortunately, investigation of various data about swordfish and marlin in this locality show the reports to be based, not on the season when the fish are present, but on the season when they are being commercially fished.

A breeding ground of *Xiphias gladius* L., the swordfish, is known off northern Sicily, in and around the Strait of Messina, where Sella and Sanzo have been able to study the life cycle from egg to adult; and another mass spawning ground has been reported in the Black Sea (Slastenenko, E. P., Ann. Sci. Univ. Jassy, 22, 1936: 293, quoting Professor Knipowitsch who received such information from V. Vodianitsky). Larvae of the swordfish have been picked up in the Gulf Stream off Florida, but not in quantity, and in isolated cases in various other localities. Juvenile stages from 2 pounds up have been found in numbers off Sicily, in the Bosphorus, and off the Hawaiian Islands.

The ovaries sent us with those of the blue marlin were taken from a fish caught by commercial fishermen on September 9, 1942, off Cojimar, on the northern coast of Cuba. They measured 2 feet in length and 5 inches in greatest diameter. The eggs are ready to rupture the membrane. We also have data and photographs of 25-pound ovaries from another swordfish weighing 300 pounds, taken by market fishermen on August 19, 1941, while drifting for marlin off Cojimar. Fishermen and anglers claim that swordfish in this state are frequently found in this locality, often accompanied by another much smaller fish, presumably the male.—F. LaMonte, *American Museum of Natural History, New York City.*

THE SYNONYMY OF *MYOXOCEPHALUS AENEUS* AND *MYOXOCEPHALUS MITCHILLI*.[1]—The name "*Cottus Mitchilli*" was first suggested by Cuvier and Valenciennes (1829, Hist. Nat. Poiss., 4: 188) for a fish which Mitchill (1815, Trans. N.Y. Lit. and Phil. Soc., 1: 381) had described as being identical with *Cottus* (now *Myoxocephalus*) *scorpius* (Linnaeus). Mitchill's description of this species was so vague that even Cuvier and Valenciennes admitted that *"le peu qu'il en dit n'est pas suffisant pour le caractériser."* They concluded that it might have been a young specimen of *Myoxocephalus octodecimspinosus* to which Mitchill had reference. Nevertheless they gave this fish a name which has persisted until the present.

DeKay (1842, Zool. New York, 4: 52–54) described *Cottus mitchilli* as a species distinct from *Cottus aeneus,* and Günther (1860, Cat.-Acan. Fish Brit. Mus., 2: 164) followed this author by listing *Cottus mitchilli* in his catalogue. On the other hand, Jordan and Evermann (1898, Fishes North and Mid. America: 1972) recognized the

[1] The writer wishes to express his gratitude to Daniel Merriman of the Bingham Oceanographic Laboratory, Yale University, for suggesting the problem and offering comments upon the manuscript. He is also indebted to Herbert E. Warfel and other members of the Bingham Oceanographic Laboratory for assistance in collecting and for reading the paper.

identity of *Cottus mitchilli* and *Cottus aeneus* and combined these two supposed species under the name *Myoxocephalus aeneus,* both of which designations have priority.

Notwithstanding Jordan and Evermann's correct interpretation, the name *Myoxocephalus mitchilli* has appeared now and then in the literature; hence an additional note on the status of the species is in order. Nichols (1916, COPEIA, 31: 140), commenting upon a fish which Roy Latham had identified as *M. mitchilli,* pointed out four differences between this specimen and a typical *M. aeneus:* (1) The body color in general was darker in *M. mitchilli* than in *M. aeneus.* (2) The ventral fins had three or four bold, black cross-bands, broader than their white interspaces, whereas in *M. aeneus* these fins were faintly marked. (3) The back of the former was less elevated than in the latter. (4) The spinous dorsal was more elevated, especially posteriorly, than in *M. aeneus.* Nichols indicated at that time that no satisfactory structural difference had been found between the two species. Indeed he stated, "It is possible that recent authors are correct in synonymyzing the forms, but they look different." Breder (1925, COPEIA, 144: 52–56) wrote an exhaustive account of the coloration in life of *M. mitchilli* which he compared with that of a specimen of *M. aeneus* as described by Nichols. Breder concluded that "unless the two species should be shown to intergrade there appears no good reason at present for considering them identical."

The solution to this problem became apparent to the present writer while identifying shore fishes collected at Morris Cove, New Haven, Connecticut, in 1942 and 1943. These specimens were studied fresh and after preservation in 10 per cent formalin. During this study both color types were found, although the *M. aeneus* form was much the commoner of the two. It seemed likely that the striking color difference was merely a case of sexual dimorphism, all *aeneus*-like fish being females, all *mitchilli* being males. Such a differentiation of the sexes is well-known in *Myoxocephalus scorpius* of the North Atlantic where the darker coloration and the higher dorsal and anal fins of the males caused Swedish fishermen to regard the sexes as distinct species (Gill, 1905, Smithsonian Misc. Coll., 47(2): 348–359).

Microscopic examination of the gonads of the 40 specimens of *M. aeneus* and *mitchilli* caught at intervals over a period of one and a half years at Morris Cove revealed 5 males with the characteristics usually assigned to *M. mitchilli* and 35 females with the characteristics of *M. aeneus.* Unfortunately only two of the males were mature (83 and 85 mm.). Both of these showed: (1) the dark (almost black) coloration of the body; (2) the four distinct bars on the ventral fins; and (3) the high spinous dorsal fin. However, each of the immature males was darker than any female in color, and the bars on the ventral fins were better defined than in any of the females. The females were brassy in color and had indistinct, diffuse bars on the ventral fins. The spinous dorsals were slightly lower on the whole than those of males with similar body proportions.

All specimens at the American Museum of Natural History catalogued as *Myoxocephalus mitchilli* were examined, through the courtesy of Dr. J. T. Nichols. Two of these were determined definitely to be males. The four remaining specimens were in such a state of preservation as to make gonad identity uncertain, although they certainly contained no eggs. In view of the fact that three of the four specimens were collected on December 4, which is close to the spawning season, females could have been identified easily by the presence of large eggs. Therefore the specimens were probably males. All 6 specimens catalogued as *M. mitchilli* showed the dark coloration and other characters peculiar to males. Seven specimens catalogued as *M. aeneus* were examined also. Of these, 5 contained eggs and were of the typical brassy hue with indistinct ventral fin bars. One was a male and agreed in coloration with those labelled *M. mitchilli* as described above. In the other case the sex could not be determined.

Finally 28 specimens collected by the New York Biological Survey (Greeley, 1938, Suppl. 28, Ann. Rept. N. Y. Cons. Dept.: 189) were loaned by the late Dr. Dayton Stoner of the New York State Museum. They were labelled *M. mitchilli,* and turned out to be immature females,[2] their color agreeing with that of females described above.

With regard to other external characters, the description of *M. aeneus* given by Jordan and Evermann (1898, *op. cit.*) obviates extensive comment. However, during this

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[2] An interesting problem is raised by the peculiar sex-ratio of *M. aeneus.* In both the Morris Cove and the New York collections the females far outnumbered the males; indeed, in the latter case no males were found. This is the reverse of the situation in *Myoxocephalus scorpius* where Craigie (1927, Contrib. Canad. Biol., 3 (22): 491–499) found that the males were more abundant, there being 156 males and 81 females in his collections. The sex-ratios of both these species unquestionably merit further study.

study it was noted that the fin ray counts are more variable than indicated by these authors. The numbers of rays in the spinous dorsal, soft dorsal, and anal fins of the Morris Cove specimens are given in the following table:

Spinous Dorsal		Soft Dorsal		Anal	
Number of rays	Number of fish	Number of rays	Number of fish	Number of rays	Number of fish
10	8 ♀♀; 1 ♂	15	10 ♀♀	12	10 ♀♀
9	25 ♀♀; 4 ♂♂	14	17 ♀♀; 5 ♂♂	11	19 ♀♀; 5 ♂♂
8	2 ♀♀	13	8 ♀♀	10	6 ♀♀

DeKay, who recognized both *Cottus* (*Myoxocephalus*) *aeneus* and *mitchilli*, wrote concerning the latter: "The spines of the preopercle and the radial formula render it highly probable that it is a small and distinct, but hitherto neglected species." DeKay's fin ray formula for *C. mitchilli* was D. 10.14, A. 11; for *C. aeneus*, D. 10.15, A. 10. It is obvious from the data on the Morris Cove fish that these formulae might apply equally well to males (DeKay's *C. mitchilli*) and females (his *C. aeneus*), and that even greater variation may exist. With regard to DeKay's other distinctive character for *C. mitchilli*, i.e., the presence of four preopercular spines, this is a variable character also. The numbers of spines on the specimens collected at Morris Cove are tabulated here:

Preopercular Spines	
Number of Spines	Number of fish
3	26 ♀♀; 2 ♂♂
4	4 ♀♀; 2 ♂♂
3 on one preopercle, 4 on other	5 ♀♀; 1 ♂

Thus it appears that DeKay, in attempting to verify the species *Cottus mitchilli*, of Cuvier and Valenciennes, cited highly variable, non-diagnostic characters.

It seems apparent from the data presented that *Myoxocephalus mitchilli* must be considered as identical with *Myoxocephalus aeneus*, and that the difference in color is a sexual one. The specific name *aeneus* must be adhered to, since it antedates *"Mitchilli"* of Cuvier and Valenciennes.—WILLARD D. HARTMAN, *Osborn Zoological Laboratory and Bingham Oceanographic Laboratory, Yale University, New Haven, Connecticut.*

NEW BOOKS RECEIVED

POISONING BY SNAKES, PLANTS AND FISH. Medical Series I. No. 4, Arctic, Desert, and Tropic Information Center. U.S.A.A.F., New York, 1944: 17 pp.

REPTILES STUDY. By Roger Conant. Merit Badge Series, Boy Scouts of America, New York, 1944: [IV] + 63 [+1] pp., illus.

POISONOUS SNAKES OF THE EASTERN UNITED STATES WITH FIRST AID GUIDE. By Harry T. Davis and G. S. Brimley. North Carolina Bird Club Book Fund, Box 2281, Raleigh, N.C., 1944: 16 pp., 4 pls., 12 figs.

THE DANGEROUS SNAKES OF THE SOUTH-WEST PACIFIC AREA. By J. R. Kinghorn and C. H. Kellaway. Melbourne, Australia, 1943: 43 pp., 11 figs.

Reviews and Comments

NATURALIST AT LARGE. By Thomas Barbour. The Atlantic Press, Boston, 1943: XII+314 pp., 21 plates. $3.50. THAT VANISHING EDEN. By Thomas Barbour. The Atlantic Press, Boston, 1944: 250 pp., 25 plates. $3.00. —The key to full appreciation of these books is to be found in the second, "The Vanishing Eden." Ponce de Leon failed to find in Florida the Fountain of Eternal Youth which he sought. Thomas Barbour must have imbibed from some such source in his extensive travels in Florida, more than Ponce de Leon ever made, which gave his spirit, at least, that vernal touch which is so delightful in the man and in his writings. Perhaps it was from one of the great springs he describes so graphically, perhaps from one of the roadside ditches he makes so colorful and fascinating.

Realizing this quality of an eternally youthful spirit one knows that "Alice in Wonderland"' and "Through the Looking Glass" must have been read and re-read. It is not strange then that with the Walrus he finds the time "to talk of many things," and surely the range of his choice is fully as weird as "of ships and shoes and sealing wax, of cabbages and kings." The beauty of flowers and mountain cliff and gorge, the worn out rubbers of a curator in a glass jar and the gall stones of a lady, left to the museum on perpetual loan, the wonders of the fossil remains of extinct life and peculiar quirks of colleagues which the reviewer prefers to refer to a touch of persistent youth rather than to mental aberration—all these make reading of the books a realization of what the Walrus envisaged, a joyous talk fest.

Springs have through all history had a touch of mystical power attributed to them. We see in Barbour's reminiscences the influence of the fountain of eternal youth, only rarely do we suspect that he has made a trip to Arizona and sipped from the Hassayampa River. The possible influence of that stream crops out in his tale of a coon surrounded by a cloud of mosquitoes so thick that only occasionally could the coon be seen.

The world is rich with nature lovers whose hearts are lifted and days brightened by glimpses of the intimate life of animals and plants, but who are inhibited from sharing their joy by spoken or written words. It is an occasion for rejoicing when the rare individual appears who can vocalize the pleasure of minor incidents as well as of heart moving experiences. Reading his books, the silent naturalists can say: "Ah, I saw something like that. I felt the same uplift so beautifully expressed here. A blessing on the pen that tells what I have felt."

The reader who has followed wild trails himself and the reader who has only dreamed of far horizons will enjoy, each in his own way, these tales by a "happy warrior" who has journeyed far and met strange beasts and birds and plants and men, and has the ability and good will to let us share the joy in nature of an eternally youthful spirit.—Ermine C. Case, *Museum of Paleontology, University of Michigan, Ann Arbor, Michigan.*

BRAZILIAN BOOKS OF INTEREST TO ICHTHYOLOGISTS AND HERPETOLOGISTS.—In a previous review (Marcgrav, *Historia Natural do Brasil*) I have mentioned the recrudescence of the Brazilian publishing business and the large number of books of interest to naturalists now being published in Brazil. Comparatively few of these books are known to North American zoologists and it has seemed to me to be of value to call some of them to the attention of readers of COPEIA. The notices given below are not intended as reviews, and I have departed from the usually accepted custom not only in listing some older books but also in including some papers which for one reason or another have had no wide distribution. A number of the works listed did not receive notice in the *Zoological Record*. Some even are out of print and rare, but may occasionally be obtained in some of the better second-hand book shops in Rio. Of the latter I may mention especially the three following: Livraria J. Leite, Rua São José 80; Editoria Civilização Brasileira, Rua Ouvidor 94; and Livraria Kosmos, Rua Rosário 137. All three also deal in new books, publish some works themselves, and are accustomed to doing business with foreign buyers. The first mentioned is one of the very few houses which specialize in Brazilian serials. It should be mentioned that most Brazilian books, as in France, are published in paper covers; if one wishes the book bound he pays extra or takes it to a binder. Binding is of fair quality, cheap by American standards, and usually done in half leather (seldom three-quarters or full leather). Paste-filled cloth or buckram bindings are quickly attacked by mould and roaches in the tropics; a good American buckram binding is a shambles after a year in Rio.

Da vida dos peixes. By Rodolpho von Ihering. 151 pp., 15 figs., 3 folding plates. Companhia Melhoramentos de São Paulo. 1929. Cr$8.—The best small popular book on Brazilian fresh-water fishes, their habits, and their propagation.

Da vida dos nossos animais. By Rodolpho von Ihering. 319 pp., 629 figs. Rotermund & Co., São Leopoldo, Rio Grande do Sul. 1934. Cr$20. The best, and in fact, the only good, popular, readable, well-illustrated manual of the common animals of Brazil. It covers all groups and includes nearly every species the ordinary traveller is likely to meet with. The vertebrates take up more than half the book, and the invertebrates, especially the marine ones, receive weak treatment. This is one of the few Brazilian books with an alphabetical index.

Dicionário dos animais do Brasil. By Rodolpho von Ihering. 899 pp., numerous figures. Departamento da Industria Animal, São Paulo. 1940.—This is an exceptionally complete and painstakingly edited alphabetical dictionary of the common and native names of Brazilian animals, and as such is of interest to all who collect or study the fauna of the country. It ends with an alphabetical index to the scientific names, with the common names opposite, and a grouping of the common names by zoological groups. Dr. von Ihering died just before its publication and few, if any, copies reached his friends in North America. Unfortunately, like most governmentally issued publications in Brazil, the book was distributed gratis far and wide, soon went of of print, and can now only occasionally be obtained from second-hand shops. Bound copies bring a price in the neighborhood of $7.50, American.

Do Rio de Janeiro a Cuyabá. By Herbert H. Smith. 372 pp. Companhia Melhoramentos de São Paulo. 1922. Cr$8. Few American zoologists are acquainted with one of the best books on zoological travel in Brazil, H. H. Smith's *Brazil, the Amazons and the coast* (New York, 1879). Like Bates, Smith was an entomological collector, but he was also a geologist (a student and co-explorer with Hartt in Brazil), and his ichthyological and herpetological collections formed the basis for some of Cope's papers. Still fewer know that Smith published a second work on his Brazilian travels, in Portuguese, in 1886. The book now under notice is a second edition of the Portuguese work, which describes a trip from Rio to Matto Grosso.

Zoo-geografia do Brasil. By Candido de Mello Leitão. 417 pp., 133 figs. "Brasiliana," [a series of small books on Brazil], vol. 77. Companhia Editora Nacional, São Paulo. 1937.—An account of general and Brazilian zoogeography, the first work of its kind to be published, but marred by numerous errors in the sections on vertebrates. One new generic name for a Brazilian frog is proposed (*Fritziana*, nom. nov., p. 330, to replace *Fritzia* Miranda-Ribeiro, preoccupied), which was not mentioned in the *Zoological Record*. Unfortunately (or fortunately, as one sees it) the edition of this book seems to have been very small and it is now out of print. I could find it in no shop in either

Rio or S. Paulo, but finally obtained the last one for sale in Bello Horizonte.

O Campo. Revista de lavoura, pecuaria, industriais rurais e estudios economicos. Rio de Janeiro. 1930–date.—This monthly farm journal, almost entirely unknown outside Brazil, served for a time as an important vehicle for the publication of papers on systematic zoology, including ichthyology and herpetology. The important papers in these two fields nearly all appeared in volumes 8 and 9 (1937 and 1938), at a time when, for various reasons, other openings for the prompt publication of systematic papers were nearly non-existent in Rio. Certain entomological, fish cultural, and mammalogical papers appeared both before and after the years mentioned. Fortunately, avenues for the publication of systematic papers have increased, the editorship of O Campo has changed, and the journal is no longer of importance to the systematist. The old volumes can no longer be obtained. In volumes 8 and 9 there are several papers by Miranda-Ribeiro on new Brazilian amphibians, reptiles and fishes; a series on Brazilian zoogeography (running through nine issues and containing the description of a new genus and species of Characins, *Utiaritichthys sennae-bragai,* not included in the *Zoological Record*) by the same author; numerous descriptions of new insects, two important papers on the habits and ecology of amphibians and bats by Carvalho, and many other zoological contributions.—GEORGE S. MYERS, *Museu Nacional, Rio de Janeiro, Brazil.*

THE FISHES OF THE BERING SEA AND NEIGHBOURING WATERS, ITS ORIGIN AND ZOOGEOGRAPHY. (Title as published; translated more exactly would be: OUTLINE OF THE ZOOGEOGRAPHY AND ORIGIN OF THE FISH FAUNA OF THE BERING SEA AND ADJACENT WATERS.) By Anatoly P. Andriashev. Publication of Leningrad State University, Leningrad, U. S. S. R., 1939: 1–187, figs. 1–16. (In Russian, with English summary pp. 181–185 and English table of contents p. 187.)—This excellent publication, which forms the author's dissertation for the degree of Candidate of Biological Sciences (equivalent of M. A. degree), is by far the most important and comprehensive modern study of the fish fauna of the Bering Sea. There is an up-to-date bibliography of 311 titles. Most of the figures consist of maps showing distributional or hydrographic data.

The author reviews briefly the basic works dealing with the fish fauna of the area, presents a summary of the existing knowledge of the physico-geographical conditions in the Bering and Chukchi seas, in connection with the limited data on the ecology of the fishes, discusses the composition and character of the fish fauna of these seas, the origin of some of its elements, and the zoogeographical division of the area, and summarizes his findings and presents conclusions.

It is gratifying to see at this time the appearance of such a comprehensive summary and critical review of the scattered data on the fish fauna of the Bering Sea. Despite the existence of numerous publications, this vast area (about 2¼ million square kilometers) is still very imperfectly known with respect to the composition, relationships, distribution, and ecology of its fish fauna. Ecological data in particular are lacking in the great majority of the ichthyological works dealing with the Bering Sea, and when given, are composed often only of depths; rarely are data regarding character or composition of the bottom, salinity, or thermal conditions included. Discussion of the relation of the fauna to faunas of other areas and to environment is therefore especially valuable.

As the author points out, the history of the investigation of the fish fauna of the Bering Sea is characterized by two periods of activity. The first is that of American investigators, during the last third of the past century and the beginning of the present one, and is connected primarily with the colonization of Alaska and the development of its natural resources. The second may be called the Soviet period. The investigations of this period, begun in the Bering Sea but recently, form a part of the broad program of the study of the far-eastern waters of the U. S. S. R., connected with the general development of the economy of the Far Eastern Region and, more recently, with the utilization of the Northern Sea Route.

These investigations received impetus with the founding in 1925 at Vladivostok of the Pacific Scientific-Commercial Station "Dalryba," later expanded into the Pacific Institute of Fisheries. A whole series of expeditions, the extent of which was widened with the organization of the far-eastern trawler fleet in 1930, was conducted by this institute.

In particular, the year 1932 is marked by an unprecedented rise in the investigation of far-eastern waters, due to the organization by the Pacific Institute of Fisheries and the State Hydrological Institute of the Pacific Ocean Expedition, composed of three parties: Japan, Ohotsk, and Bering. Trawl hauls in the Bering Sea were made not only over the continental shelf, but also to a depth of 3,800 meters. It will be a surprise to many American ichthyologists to learn that these expeditions have done very thorough work in the eastern as well as the western portions of the Bering Sea. Vast collections of fishes have been made, and these collections will be of particular value because of the accompanying store of hydrological data. Modern techniques and methods of investigation have been employed, so that the faunas of these waters have been studied as integrated units. The results of investigations made are not yet all published and this period may be said just now to be coming into bloom.

In his studies, e.g., in his account of hydrological conditions in the Bering Sea, the author draws heavily on the literature, but does this critically, summarizing the results and then utilizing these data for the development of his own studies and conclusions.

It is inevitable that in a work of such a wide scope, in which the author must rely on published data, some errors will appear. Such errors (for example, regarding the distributional range of various species of fishes), are noticeable occasionally, but appear to be of minor importance as regards the basic conclusions and worth of the publication.

The zoogeographical division of the north Pacific Ocean has been a controversial point for nearly a hundred years. The author stresses the fact that the present distribution of the fish fauna of the Bering and Chukchi seas is dependent upon paleo-climates as well as upon present-day ecological factors. He traces the development and migrations of various elements of the fauna during different geological periods. Studies of the interaction of paleo-climates and present-day ecological factors unfold beautifully to explain the differences as well as the similarities between the fish faunas of various portions of the area.—LEO SHAPOVALOV, *California State Division of Fish and Game, Stanford University, California.*

THE WOODS HOLE MARINE BIOLOGICAL LABORATORY. By Frank R. Lillie. University of Chicago Press, Chicago. IX + 269; several figures. $4.00.—To those lucky enough to have spent one or more summers at Woods Hole, this book will bring back warm and pleasant memories. It is a history of the Marine Biological Laboratory, set down by two men who shared in the enthusiasm that went into its early development. The geography and early history of the town, the origin of marine laboratories in Europe and America, the founding, growth and development of the Marine Biological Laboratory and of the Woods Hole Oceanographic Institution, as well as biographies of the early leaders are recounted.—L. A. WALFORD, *Stanford University, California.*

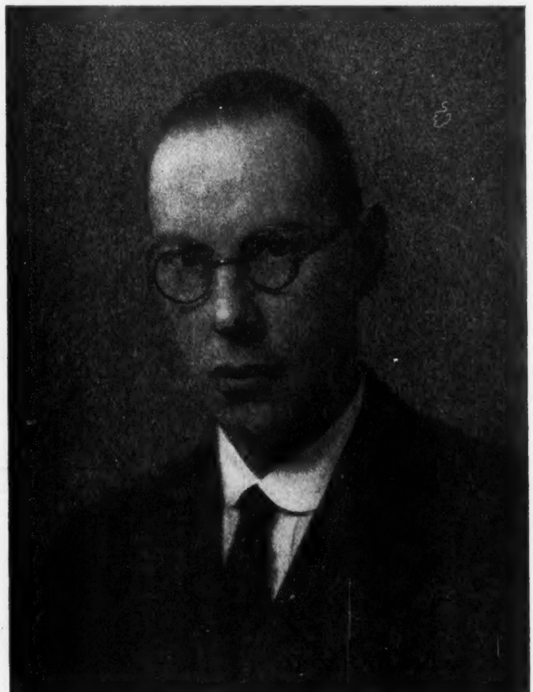
THE NEW CHEMICAL FORMULARY, Vol. 6. Edited by H. Bennett.—Chemical Publishing Company, Brooklyn, N. Y., 1943: XX + 585. $6.00.—As its subtitle indicates, this is a collection of practical commercial formulae and recipes for making products in many fields of industry. The laboratory technician and field worker who frequently must improvise and make his own apparatus, will find *The New Chemical Formulary* full of useful information. Aquarium cement, formaldehyde deodorant, formaldehyde substitutes, insecticides, waterproofing, rust preventive paint, are a few pertinent titles taken at random from the index.—L. A. WALFORD, *Stanford University, California.*

INTELLIGENCE, POWER AND PERSONALITY. By George Crile. Whittlesey House, New York. VI + 332, 42 figs. $3.00.—The central thesis of this book is that intelligence, power and personality are dependent on the absolute and relative size of the brain, the thyroid gland, the heart and blood volume, the celiac ganglia and plexuses, and the adrenal-sympathetic system. The author, in the course of big game hunting and fishing expeditions, has amassed a large body of quantitative data, representing many groups of animals from earthworms to man. This he presents in an ingenious and provocative argument to explain differences in the behavior, physical requirements and habitat of animals.—L. A. WALFORD, *Stanford University, California.*

EDITORIAL NOTES AND NEWS

John R. Norman

JOHN ROXBROUGH NORMAN, Deputy Keeper in the British Museum (Natural History), died in May of this year at the age of 45, after months of struggle with the streptococcus of endocarditis.



JOHN R. NORMAN

Norman's health had never been good since an attack of rheumatic fever during the war of 1914–18 ended in his being invalided out of the army. For this reason he never ventured to risk the vicissitudes of travel and field work. With the help and support of his wife he courageously adjusted himself to the routine that suited him, and lived a full and cheerful life within the limits it imposed. He was a tall man, with a high, narrow head, quick speech and an unfailingly courteous manner. His chief pleasure was in conversation with his friends, and he also took a great interest in the theatre and himself wrote two plays for an amateur dramatic society of which he was a member. He enjoyed, too, as we all do, meeting and corresponding with foreign ichthyologists, and his election as a Foreign Member of the American Society of Ichthyologists and Herpetologists pleased him very much.

To understand his work it is necessary to realize that he got almost as much pleasure in setting known facts in order and making them available for reference, as in discovery. He used to say that a couple of years spent in a bank between the ages of 16 and 18 had taught him the value of method. There is no doubt that the very large amount of work he got through was only possible because he ordered his days strictly, kept neat records of everything, and did not allow himself to be sidetracked by the many unexplored paths whose openings he could not fail to see in handling the wonderful material on which he wrote his fine taxonomic reports. The works which his name immediately calls to mind are his monograph of three families of flatfishes, his four big reports on the fishes of the "Discovery II" expeditions, and those on the British, Australian and New Zealand Antarctic Expedition and the Murray Expedition to the Indian Ocean. These works and many smaller papers appeared during the years 1930–39. This, naturally his most productive time, saw also his complete reorganization of the Fish Gallery of the Museum, the publication of his guide-book to this exhibition, and his popular "History of Fishes," as well as his share of "Giant Fishes, Whales and Dolphins." His successors have reason to bless him further for the indexes he built up. Günther's "Catalogue" had been kept up-to-date, as far as listing goes, in the interleaved copy, and Norman had put a considerable part of this on to cards. Col. Tenison (who was all along associated with him as illustrator) had been making a manuscript ledger of these lists. Norman made an index of the genera of fishes and kept it up-to-date, and the filing and indexing of correspondence was an innovation introduced by him. He thought that the time was past when one person could hope to issue a new edition of a descriptive "Catalogue of Fishes," but he embarked on the task of making a synopsis and keys of all the families and genera of fishes. When the war came, collections and libraries alike became unavailable, and he had to put this great work temporarily aside. Dr. G. S. Myers was, I believe, undertaking certain groups and it is hoped that the task may be completed.

The qualities so illustrated, and his equable temper and courteous and friendly manner, had marked Norman as one to whom higher administrative responsibilities would fall, and his death is a great loss to the British Museum in this sense no less than as a man of science.—ETHELWYNN TREWAVAS, *British Museum.*

Honor Roll

ADDITIONS to and changes in the list of Society members in the U.S. armed services are: W. L. BURGER, JR., U.S.N.R.; CAPT. FRED CAGLE, Army Air Corps; CADET JOHN W. GRENSHAW, U.S. Army; PH.M., 2/c MICHAEL F. GROVES, U.S. Navy; T-5 RICHARD M. JOHNSON, U.S. Army; LT. F. WILLIS KING, U.S. Army; CPL. CARL KURTZ, Army Medical Corps; LT. JAMES OLIVER, U.S. Navy; PVT. NEIL D. RICHMOND, U.S. Army; COL. EDWARD R. TAYLOR, U.S. Army.

BENJAMIN SHREVE, after two and a half years of active service in the Army, has been honorably discharged and has returned to his duties in the Museum of Comparative Zoology, Cambridge.

We regret to announce the death of FRED BROMUND, from wounds received in action in Germany. Formerly a herpetological student in the Museum of Zoology, University of Michigan, he had been more recently teaching in Michigan schools. He was an able student with a deep interest in herpetology, and a good friend. He is survived by his wife and small son Waldo.

Recent Deaths

NEWS has been received of the death of DR. SIMON HENRY GAGE of Cornell University, known to herpetologists mainly for his publication on amphibian life histories, and to ichthyologists for his extensive work on the life history, anatomy and phsyiology of lampreys. He was 93 years old, and active almost to the last.

ARTHUR SMITH WOODWARD, one of the world's outstanding paleichthyologists, died on September 2, at the age of 80. He was head of the department of geology at the British Museum from 1901–1924.

News Notes

DR. THOMAS BARBOUR has been appointed, by the unanimous action of the Board of Governors, Honorary President of the Society, to succeed the late DR. LEONHARD STEJNEGER. It is most appropriate that JOHN T. NICHOLS, the founder of COPEIA, and THOMAS BARBOUR, who has, for so many years, served as a kindly and wise advisor to our members, should share the highest honor the Society has to offer them.

VERNON E. BROCK, formerly chief fishery biologist with the Fish Commission of Oregon, and more recently administrator of pilchard production and production analyst in the office of the Coordinator of Fisheries in San Francisco, has been appointed Director of the Division of Fish and Game of the Board of Agriculture and Forestry of Hawaii.

The following note has been received from DR. GUDGER: The completion of the "Bashford Dean Memorial Volume: Archaic Fishes" has left on my hands considerable numbers of plates left over from making up the various articles in the volume. Desirous of placing these where they will be appreciated and used, I will be glad to send these gratis to teachers and students of embryology and comparative anatomy who wish them. Address requests to: E. W. GUDGER, Editor, Dean Memorial Volume, American Museum of Natural History, West 77th St., New York 24, N.Y.

DR. GUSTAV A. SWANSON, formerly associate professor of zoology at the University of Minnesota, has been appointed biologist in the Division of Wildlife Research, U.S. Fish and Wildlife Service, with headquarters in Chicago, at the central offices of the service.

American ichthyologists, who were pleased to learn that DR. LEO S. BERG and DR. PETER J. SCHMIDT had survived the siege of Leningrad and were continuing their work in western Siberia (COPEIA, 1944, No. 1), will be happy to have good news of another outstanding Russian ichthyologist and fisheries specialist, PROF. I. F. PRAVDIN of Leningrad University. Prof. Pravdin is best known in this country for his studies on the humpback salmon and on the biology and systematics of coregonid fishes. He writes from Saratov, to which Leningrad University was evacuated in March, 1942, and where he has been conducting investigations on the rearing of carp. Prof. Pravdin expresses hope that with the lifting of the siege of Leningrad, the University will soon be moved back. Since his letter to the undersigned was dated February 27, 1944 (received August 18), it is not unlikely that the staff is now back in its former quarters. Prof. Pravdin's address is: Leningrad State University, Leningrad, U.S.S.R.

The Karelian Scientific-Investigational Fisheries Station, of which Prof. Pravdin was formerly the director, was destroyed in the fighting, but manuscripts were saved.—LEO SHAPOVALOV, *California State Division of Fish and Game, Stanford University, California.*

NATURAL HISTORY BOOKS (6843 Hobart Ave., Chicago 31, Illinois) announces that the firm is now the American agent for the Zoological Record. Orders placed for the Pisces ($1.30) and Amphibia and Reptilia ($.80) sections will be filled as each section is issued.

DR. and MRS. E. R. DUNN have returned to Haverford after a profitable year spent in investigating the Colombian herpetological fauna in the Bogotá region.

Aid in publishing the plates and figures of this issue has been received from the SPECIAL GIFT FUND of the Society and from the UNIVERSITY OF CALIFORNIA AT LOS ANGELES.

Errata

IN COPEIA (3), 1944, in the article on "Sexual Maturity in the Female of the Turtle *Pseudemys scripta elegans,*" by Fred R. Cagle, on page 150, 27th line, for "60 mm." read 160 mm., and on page 151, under Literature Cited, 2nd line, for "Pl. 3" read Pt. 3.

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New names and their principal references are printed in bold face type.

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